IUGG Quadrennial Report Overviews

Volcanology, Geochemistry, and Petrology 1979–1982

David E. James
Carnegie Institution of Washington, Washington, DC 20015

This introduction to the Volcanology, Geochemistry, and Petrology (VGP) section of the 1979–1982 IUGG Quadrennial Report is intended to serve as a thumbnail sketch of some major research developments and trends in VGP over the past four years. These notes are drawn from, and limited to, the nine review articles that follow in this section. Although I have made an effort to give mention to all areas covered by the reviews, the subjects about which I know most have inevitably received the greater play. A full reading of the reviews will provide a more balanced summary.

One particularly vigorous area of research has focused on characterizing the nature and scale of mantle heterogeneity and relating that heterogeneity to crust-mantle evolution. The popular model of a two-layered mantle, consisting of a depleted upper mantle from which crustal material was presumably extracted and of a lower undepleted layer of primordial material, has recieved considerable attention both pro and con, and a number of quantitative treatments based on the layered mantle model have been published to describe trace element transfer between crust and mantle. Despite great efforts to describe mantle heterogenity in terms of time-dependent mantle dynamics and processes of chemical differentiation, the number of models still approaches the number of workers studying the problem. Actively debated has been the role of ancient subducted oceanic crust, suggested by some to comprise third mantle reservoir from which at least some oceanic island basalts are derived. The subcontinental lithospheric mantle may comprise yet a fourth mantle reservoir, and evidence continues to mount that it is chemically distinct from suboceanic mantle, that in some regions it is relatively enriched in incompatible elements, and that it has been isolated from the rest of the earth's mantle for billions of years.

Several important new developments in isotope geochemistry bear directly on studies of chemical differentiation in the earth.

1. A revolutionary advance has been the use of the ^{10}Be isotope (half-life 1.5 m.y.) to study recycling of subducted sedimentary material in island arcs. Virtually all ^{10}Be is produced by spalation processes in the upper atmosphere. In the oceans it accumulates almost entirely in the upper few meters of sedimentary material. Preliminary measurements, using a Van de Graaff generator as a sensitive mass spectrometer, have already demonstrated the presence of ^{10}Be in most island-arc volcanic rocks studied—the first *direct* evidence that island-arc magmas are derived in part from the downgoing oceanic plate.

2. Recent measurements of $^3He/^4He$ ratios have shown large-scale variations in volcanic rocks of mantle origin. Some "hot spot" volcanics have high $^3He/^4He$ ratios (15–30 times that of atmospheric helium) that are commonly interpreted as "primordial," whereas mid-ocean ridge basalts and island-arc volcanics have ratios less than 10 times that of atmospheric helium. Interesingly, however, the bulk of oceanic island hot spots, some of which exhibit high $^{87}Sr/^{86}Sr$ ratios and others that do not, have $^3He/^4He$ ratios close to or even lower than those of mid-ocean ridge basalts. These results, as yet largely unexplained, introduce complexities that could seriously compromise simply two or even three reservoir models of the mantle.

3. A new radiogenic isotope technique that came of age during the quadrennium utilizes the decay reaction ^{176}Lu to ^{176}Hf. Hf measurements have already placed some important and unexpected constraints on mantle evolution. Despite the fact that Lu and Hf are highly refoctory and should behave similarly to Sm and Nd, Hf isotopic heterogeneity in the mantle has apparently remained unchanged over the past 2.8 b.y., whereas Nd indicates an almost two-fold change in the degree of mantle heterogeneity. The problem remains unresolved.

4. The past quadrennium has seen a marked increase in the use of oxygen isotopes in combination with radiogenic isotopes, particulary in continental igneous rocks, to identify crustal contamination in magmas of presumed mantle origin. The combined use of stable and radiogenic isotopes is part of a more generol move by geochemists to utilize all available analytical tools to constrain petrogenetic models. In part this move has evolved in response to increased recognition that in addition to partial melting and fractional crystallization other magmatic processes such as magma mixing, assimilation, and metasomatism can influence magmatic compositions in important ways which may not be entirely obvious.

Studies of magma mixing have focused largely on understanding the mechanism by which fractionated products are mixed with fresh injections of cogenetic magmas in a complexly evolving magma chamber. Such mixing, while not affecting isotopic compositions, can apparently produce significant deviations from expected fractionation paths, especially for trace elements.

The past four years have brought recognition anew that crustal contamination involves both assimilation and reactional crystallization. It is now known that although these combined processes may produce liquid lines of descent for major elements that differ little from normal differentiation, the effects on isotopic and trace element compositions can be profound. This "discovery" has been a primary motivation for using such crustal indicators as oxygen isotopes to detect small amounts of crustal contamination in mantle derived magmas.

Soret diffusion and double-diffusive convection received considerable play during the quadrennium as possible mechanisms for producing compositional gradients in magma chambers and layered complexes, but there is as yet little hard evidence that these processes are important in the real earth.

Work continues to focus on the effect of H_2O, CO_2, and other volatiles in magmatic processes, including partial melting and differentiation. Particular emphasis has been on mantle metasomatism because it relates to mantle heterogeneity and because it seems to play an important role in diatreme magmatism. The extent and scale of mantle metasomatism are still virtually unknown, however, and appear likely to remain so until we can devise better means of distinguishing primary variations in mantle source rock compositions from the overprint of modifying influences that affect melt compositions during partial melting and magmatic ascent.

The motion and behavior of volatiles also comprise a lively area of research activity in metamorphic petrology. Of particular importance has been the increased use of stable isotopes (chiefly oxygen) integrated with petrologic information to examine fluid-rock interactions, including fluid abundances and mechanisms of migration. There has been increased interest also concerning the effects of fluid flow on the distribution of heat during metamorphism and on the location of isograds.

In the area of metallogenesis, the most exciting development has been the discovery of "smokers"—active vents situated on seafloor spreading centers and around which are found concentrically arranged deposits of highly concentrated zinc, copper, and iron sulfide ores. These deposits have evidently been extracted from the hot basalt overlying the shallow (1.5–2.0 km) ridge-crest magma chamber by action of deep hydrothermal systems where seawater convects through the basalt. The discovery of these hydrothermal systems has resulted in an expanded research effort aimed at understanding the interaction of hot seawater with oceanic crust and mechanisms for the hydrothermal transfer of metallic and trace elements.

Notable progress has been made over the past four years in developing genetic models for the origin of mineral deposits. The marked turn from empirical to genetic models has been aided in large measure by advances in three areas: (1) analysis of fluid inclusions to obtain information on the environment of emplacement of epigenetic ore deposits; (2) study of phase relationships to provide thermodynamic information, including the nature of partly equilibrated systems, useful for determining time intervals of mineralization, metamorphism, or pluton unroofing; and (3) study of aqueous solutions to predict properties and behavior of complex solutions respsonsible for mineralization.

Efforts to relate ore deposits to various plate tectonic environments or processes continue to meet mixed success. The possible link between the subduction and melting of metalliferous oceanic sediments and the formation of ore deposits in volcanic arcs (the "geostill" hypothesis) remains unconfirmed and is likely to remain so until much better models are developed for magmatic processes in subduction zones.

Research on rock-forming silicates continues to focus on equilibrium phases assemblages and the uses of mineral or coexisting mineral properties to deduce the P-T history of rocks. A rapidly developing area is in diffusion related experiments, especially those involving element partitioning between coexisting minerals or minerals and a melt or vapor phase. Continuing research efforts produced a number of new geothermometers and geobarometers with geological applications for determining pressure and temperature from mineralogic phase equilibria.

In the field of experimental petrology, the diamond window, high pressure cell has now been used to produce experimental pressures to 1.7 Mbar, at temperatures in excess of 4000 K. The experiments have yielded information on a large class of physical properties of minerals, oxides, and metals at P-T conditions of the lowermost mantle or outer core.

The eruption of Mount St. Helens was unquestionably the most important volcanological event of the quadrennium in the United States, publicly and scientifically. Eruptions on Mount St. Helens began March 27, 1980, and reached maximum intensity on May 18 when more than 60 people were killed in a volcanic blast and debris avalanche. The Mount St. Helens eruptions provided a wealth of information on volcanological processes and served to focus U.S. attention on processes of explosive volcanism. Interest in Mount St. Helens has also led to much improved techniques for predicting eruptions. Of public as well as scientific interest also have been a number of seismic determinations indicating the possible presence of relatively shallow magma bodies beneath tectonically active areas in the western United States, including Long Valley, California, Socorro, New Mexico, and Yellowstone Park.

Either directly or indirectly, much of the research effort in VGP over the past four years has been aimed at understanding results in terms of a mobile earth. The broader implications for VGP of the revolution in ideas set in motion by the discovery of seafloor spreading are still being actively sorted out. The past four years has perhaps been the most rigorous period ever for VGP, as the handwaving speculations of the previous decade came under more controlled scrutiny, and the search for quantitative models consistent with other geophysical and geological constraints proceeded in earnest. Needed in the next four years is a major effort toward synthesizing all available geochemical and petrologic data in a coherent model of crust-mantle evolution and mantle differentiation, a model that ought also to incorporate essential structural and dynamical (especially convective) constraints on nature of the mantle. The possible role of subducted oceanic crust will have to be factored into such models.

A difficult task facing VGP in the next quadrennium is to achieve a better understanding of magmatic and geochemical processes in subduction zones. Knowledge of those processes is crucial to obtaining estimates of the contribution of the downgoing slab to island-arc and continental-arc magmatism, a key variable in models of crustal evolution. The new ^{10}Be technique is the most promising method for direct quantitative assessment of the slab contribution, although other isotopic systems should continue to provide important constraints.

Tied to all of these studies should be increased emphasis on developing better models for a variety of magmatic processes, including ascent mechanisms, and for fluid and vapor transport in the mantle and crust. For all of this and more, a central need is—and is likely to remain for the foreseeable future—a much greater body of laboratory experimental data tailored specifically to problems of the deep crust and mantle.

Contents: IUGG Quadrennial Report
Volcanology, Geochemistry, and Petrology

U.S. National Report to IUGG 1979–1982

Eos is periodically publishing the 13 overviews appearing in the *U.S. National Report to the International Union of Geodesy and Geophysics 1979–1982*. The U.S. National Report was published by AGU on behalf of the U.S. National Committee in four extra issues of *Reviews of Geophysics and Space Physics* (RGSP). The discipline overviews appearing here were published with their associated papers (see Contents list at the end of each overview).

Subscribers to RGSP will automatically receive the four extra RGSP issues containing the U.S. National Report, which were mailed in June 1983. The four regular issues of RGSP are appearing as usual in February, May, August, and November. Those who do not subscribe to RGSP can still obtain the entire U.S. National Report by entering a subscription to RGSP. In addition, the report of each discipline is automatically mailed separately to those members of AGU for whom that discipline is their primary AGU section affiliation; this separate distribution is made possible by grants from the Defense Mapping Agency, National Aeronautics and Space Administration, National Oceanic and Atmospheric Administration, National Science Foundation, Office of Naval Research, and U.S. Geological Survey.

Meteorology 1979–1982

Ronald C. Taylor
National Science Foundation, Washington, DC 20550

The Atmospheric Sciences section contains 12 papers; most of the topics have been reviewed in previous reports, though not always in each one. Thus, atmospheric electricity has not been reviewed for the past eight years, and mesoscale meteorology was not reviewed in the last report. Regrettably, atmospheric chemistry is not reviewed in this one (but see the six reviews listed at the end of these remarks).

Though the following 12 reviews discuss a broad variety of topics, a common theme emerges in many of them: the significance of new instrumentation or cognate device for making improved measurements of the atmosphere. Balsley and Gage give a systematic discussion of this theme; I will mention only three devices which seem to offer unusual promise: VHF (50 MHz) doppler radar, linear polarization for meteorological radar, and lidar. The VHF radar, particularly the Mesosphere-Stratosphere-Troposphere (MST) phased array, is capable of measuring the three-dimensional field of motion with a vertical resolution and temporal sequence far beyond any conventional technique; its configuraton is flexible and is readily portable. Polarization techniques applied to existing meteorological radars are capable of measuring the evolution and distribution of water drops in clouds, and thus, inferring more accurate rainfall rates; the technique may also offer a new means of distinguishing ice and water in clouds. Though lidars have been used in the past to identify and track aerosols, additional options for using lidar to measure winds, temperature, moisture, and trace chemical constituents are now emerging; such measurements may be made from either satellites, aircraft, or the earth's surface.

New instruments and measuring techniques are vital to investigations of the physics of natural clouds, as John Hallett reminds us in his review. In addition, new ideas are emerging that explicity acknowledge the central importance of the mixing of cloudy air in determining the development and evolution of water and ice particles in natural clouds.

The microphysical environment, particularly the distribution and growth of water and ice particles and their subsequent motion, is a central ingredient of existing theories of electrical charge generation and separation. Though the relative contributions of "particles and motion" remain unresolved, doppler weather radar has played a significant role in helping to define the problem of cloud electrification; it will, doubtless, maintain this status in the near future.

In a cognate topic—weather modification—which draws heavily upon knowledge of cloud physics, Richard Dirks reminds us that although two notable attempts to modify hail and rain were statistical failures, these experiments did advance the physical understanding of clouds.

The physics of lightning continues to benefit from the use of new instrumentation, particularly devices capable of improving our knowledge of the phenomenology of lightning and the locations of charges associated with various lightning processes.

Problems of climate as well as the radiative environment of natural clouds have combined to give a renewed emphasis to several problems of atmospheric radiation. Thus, the consequences of an altered earth radiation balance owing to the increase in atmospheric carbon dioxide is a central problem, involving not only radiation, but the nature of the atmosphere's water budget, and the radiative implications of changes in cloudiness.

Mesoscale disturbances (organized thermal convection is a familiar example) have received considerable attention; their structure and kinematical properties have been described at some length by several investigators. Characteristically, theory lags description though the ideas of symmetric instability are a promising beginning.

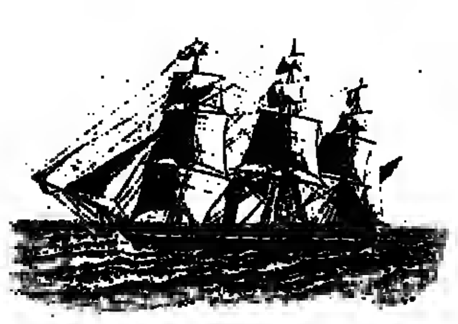
One of the more interesting and significant discoveries by both dynamical and synoptic meteorologists was the identification of mesoscale disturbances. Though these have been described at some length in the literature, relatively few attempts have been made to account for the existence of mesoscale phenomena in the atmosphere.

On the synoptic scale, some attempts have been made to identify blocking phenomena—the persistence of high pressure synoptic features in a specific geographical region—with theoretical results of multiple flow equilibria, a topic initiated by Jule Charney before his death in 1981. Also, the dynamical significance of critical surfaces or layers—where the phase speed of a wave equals the mean wind speed—continues to promote a lively discussion: Do such surfaces reflect or absorb momentum or both?

Though many scientific results have been and will continue to emerge from the Global Atmospheric Research Program (GARP), its greatest contribution may well be its own existence: the creation of an institutional appa-

Article (cont. on p. 484)

The Oceanography Report



U.S.S. Challenger preparing to sound, 1872.

The focal point for physical, chemical, geological, and biological oceanographers.

Editor: Arnold L. Gordon, Lamont-Doherty Geological Observatory, Palisades, NY 10964 (telephone 914-359-2900, ext. 325).

Sea MARC 1 Side-Scan Sonar Imaging Near the East Pacific Rise

Daniel J. Fornari, William B. F. Ryan, and Paul J. Fox

Six seamounts and many small constructional volcanic cones were recently investigated during a combined Sea MARC 1 and Seabeam survey of the East Pacific Rise (EPR) axis between 9.5°N and 13°N as part of an overall program funded by the National Science Foundation designed to characterize the along-strike morphology and structure of the axis of the EPR [*Rise Axis Tectonic Team*, 1983]. The larger seamounts studied fall into two principal categories: those that exhibit purely constructional volcanic terrain and those where the summits and flanks show significant structural and erosional features such as summit calderas (cover photo) and collapse craters and edifice flanks which have been extensively modified owing to mass-wasting processes (Figure 1). The seamounts studied include three volcanos just west of the EPR axial graben at 9°52', which form a linear group that trends N60°W. The flanks and summits of these seamounts were insonified on overlapping traverses by using Sea MARC 1 side-scan sonar and Seabeam, multi-beam echosounding. Sea MARC 1 is a midrange side-scan system developed by International Submarine Technology of Redmond, Washington, and Lamont-Doherty Geological Observatory of Columbia University, Palisades, New York. It can insonify swaths of seafloor as great as 5 km (full width) and depicts seafloor morphology and structure as small as a few meters with great accuracy. The resulting bathymetric base and sonar images have clearly identified an evolutionary pattern in the progressive structural and morphological development of these seamounts as one moves away from the EPR axis, with the details of the sonar records having important implications for constructional volcanism on the flank of the EPR.

The cover photo shows the summit plateau of MOK seamount, the third (westernmost) volcano in this group, which contains a large complex caldera that includes a 380-m deep, 2-km diameter crater at its southeastern end and two coalesced "figure 8" collapse craters extending to the northwest from it. This spatial arrangement of collapse features suggests that the principal volcanic conduit of this seamount has migrated to the southeast with time and that a shallow-level magma chamber that periodically swells and contracts controls the evolution of the caldera. The summit plateau lies at a depth of between 1900 and 2000 m and also contains a small, 20 m high volcanic cone that has produced a 2-km-long lava tube network that traverses the summit plateau in a southerly direction. Clearly, summit volcanism on this seamount has included both intra-caldera and extra-caldera eruptions with the style of constructional features bearing many resemblances to subaerial basaltic volcanic provinces.

Figure 1 shows an unprocessed side-scan record that depicts the northern flanks of all three seamounts (east is to the right) and the dramatically different edifice flanks that are the result of post- and, possibly, syn-volcanic mass-wasting processes, which have carved and grooved the sides of the middle volcano.

Studies are now in progress to analyze quantitatively all the side-scan information and combine it with the Seabeam data to produce an integrated perspective and model for the construction and morphological evolution of a seamount as well as quantitative data on seafloor acoustic reflectivity.

Acknowledgments

The field and laboratory studies involved in this seamount study project are being funded by the U.S. Navy Office of Naval Research grant N00014-80-0098 Sc SS. We thank the officers and crew of the R/V Thomas Washington and the scientific and technical personnel who all played key roles in the acquisition of this remarkable data set. Lamont-Doherty Geological Observatory contribution number 3502.

References

Rise Axis Tectonic Team, An along-strike Seabeam and Sea MARC 1 perspective of the axis of the East Pacific Rise: Implications for the accretion of oceanic lithosphere, paper presented at Symposium on Oceanic Lithosphere, Sponsor, Texas A&M University, 1983.

Daniel J. Fornari and William B. F. Ryan are with the Lamont-Doherty Geological Observatory, Columbia University, Palisades, NY 10964.
Paul J. Fox is with the Graduate School of Oceanography, University of Rhode Island, Kingston, RI 02881.

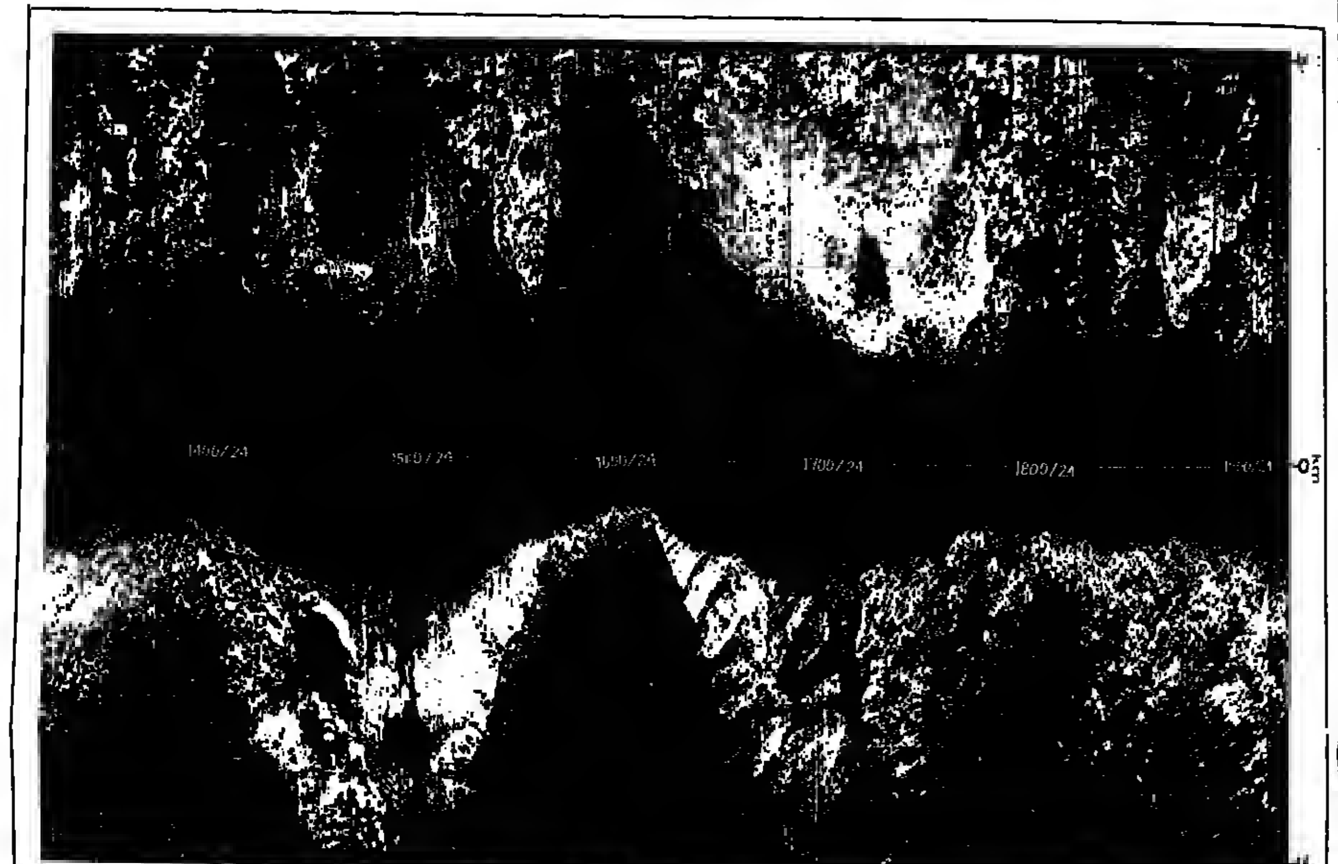


Fig. 1. Raw side-scan record showing the northern flanks of all three seamounts in this group along the bottom of the photograph. Vehicle path is along midline of image. The central volcano has dramatically different slope morphology being grooved and gullied by mass-wasting processes, which have eroded the constructional slopes and transported volcaniclastic material down the flank. This debris has spread out across the seafloor at the base of the edifice and is characterized acoustically by the smooth, nonreflective area north of the central volcano. Seafloor along the top of the photograph consists of hummocky constructional volcanic terrain with many cones (note conical shadows falling away from the midline) and lobate flow fronts.

News & Announcements

Tin in Oceans

High concentrations of tin in the North Atlantic, discovered by two Florida State University oceanographers, have been linked with waste incineration and the burning of fossil fuels in North America and northern Europe. The oceanographers say that the tin in the North Atlantic was transported there primarily through the atmosphere.

In what the National Science Foundation (NSF) is calling the first systematic study of tin in the oceans, Meinrat O. Andreae, associate professor of oceanography, and James T. Byrd, an oceanography graduate student, found that concentrations of tin are up to 20 times greater in the North Atlantic Ocean than they are in the uncontaminated equatorial and tropical Pacific Ocean. NSF funded the research.

Tin concentrations in the atmosphere are 100 times higher over the North Atlantic than over the equatorial and tropical Pacific, Andreae and Byrd found, while oceanic tin concentrations are between 5 and 10 times higher in the North Atlantic surface waters than in the surface waters of the equatorial and tropical Pacific. In addition, the tin concentrations in the waters of the Atlantic decrease with depth; in the Pacific there is little vertical change, the oceanographers found.

The tin concentrations can be a valuable tool, Andreae said, for tracing the movement of airborne pollutants from land to the oceans and as an internal tracer in the waters. Incineration of waste tinplate cans, solder, and polyvinylchlorides (PVC's) ejects tin particles into the atmosphere. Burning fossil fuels and smelting such ores as copper and zinc also are sources of atmospheric tin, the oceanographers say.

Andreae and Byrd became interested in tin concentrations because they wanted to investigate the general process of methylation of metals by microbes and, more specifically, the methylation of tin. Methylated metal compounds can be more toxic to some organisms than the free metal ions; mercury is the best known example. Organic methyltin may be as toxic as methylmercury, Andreae said, especially if the methyltin is concentrated in the relatively closed environment of an estuary, harbor, or bay.

The scientists initially concentrated their efforts on the Sargasso Sea in the Atlantic, but have since expanded to the equatorial and tropical Pacific. In continuing with their work, Byrd currently is looking at both organic and inorganic tin in the Chesapeake and Delaware bays, which are partially surrounded by heavy industry. The scientists also plan to review the concentration of atmospheric tin and the deposition of tin by rain over the North Atlantic. Next year they plan to examine transport processes.—*BTR*

New Marine Geology Center

Marine geologists at Dalhousie University in Halifax, Nova Scotia, have created a new Center for Marine Geology. The formation of the center is part of a university-wide effort to extend interests in marine research in all directions, Director James M. Hall said. The center, formed in April, will be a focus for the expansion of research in marine geology, for the development of marine instrumentation, for the expansion of advanced training of Third World geologists in marine geology, and for the university's interaction with the petroleum industry involved in a major play in the areas off the eastern Canadian shore, Hall said.

Current projects on the new center's agenda include research drilling in the ancient ocean crust of the Troodos ophiolite off Cyprus (*Eos*, July 5, 1983, p. 441), involvement with the Joint Oceanographic Institutions Deep Earth Sampling (JOIDES) program, study of the recent history of the eastern Canadian shelves through applied micropaleontology and sedimentation processes, and development of instrumentation for marine geology.

Most of the marine geologists at the center are from the teaching faculty at Dalhousie; others are from the Bedford Institute, the Canadian government's oceanographic organization. The initial members of the center are Ali Aksu, Ronald Boyd, Martin Gibling, Franco Medioli, Patrick Ryall, David Scott, and Mark Williamson. Paul Robinson is the associate director. The center's coordinator is Jane Barrett; Marggi Pavlovski is the training program coordinator. The center's technical staff, graduate students, and geoscientists total 35.

Meetings

Estuarine Research

The Seventh International Estuarine Research Conference, sponsored by the Estuarine Research Foundation (ERF), will be held October 22–26, 1983, in Virginia Beach, Va.

Session topics include stable isotopes in estuarine research; a comparison of Long Island and Rhode Island coastal lagoons; an overview of the Environmental Protection Agency's Chesapeake Bay Program; tidal mixing and plankton dynamics; tidal power and its environmental consequences; design, analysis, interpretation, and uses of long-term estuarine and coastal data sets; the physical, geological, chemical and geochemical, and biological processes involved with the estuary as a filter; the management of the estuary as a filter; an overview of the U.S. Geological Survey's Potomac Study; and tidal freshwater wetlands.

To register or for additional information, contact ERF Treasurer John Kreauter, Crane Aquaculture Facility, BC&E, P.O. Box 1475, Baltimore, MD 21203.

News

Iron Core in the Sun?

A suggestion has been made that the sun may have a central core composed of iron (*New Scientist*, June 23, 1983). This suggestion is the latest attempt to force a fit to theoretical models of the sun's internal temperature structure. That the sun does not fit well enough as a model for compositional origin of the rest of the solar system is evidenced in its apparent deficiency in the production of neutrinos. Measurements on the earth to detect the emission of solar neutrinos are typically low by as much as a factor of 3. If the core of the sun were to be composed of a sufficiently stable element, such as the form of iron that would exist at 14 million K, the production of neutrinos would be about what is observed. The result of the calculations of Carl Rouse is that the sun could have a core radius of about 5% of the total, with a density of about 1.8×10^3 kg m^{-3}. This core would be consistent with the properties of an iron plasma, instead of hydrogen and helium nuclei. In the modeling procedure one could adjust the sun's temperature to a value lowered by about 1 million K and have a lowered neutrino flux as well.

If the sun has an iron core, then other solar properties should be affected. Solar oscillations, for example, seem to compare well with iron core model calculations. What is now only an idea may be subject to vigorous test when models can be compared more closely to observations.

There are, of course, other solar system implications of the sun's having an iron core. Jupiter, for instance, is thought to have a "rocky" core, or whatever the 40 megabar equivalent is. It will be interesting to see whether planetary theorists will move quickly to try iron core models for all the planets of the solar system.—*PMB*

EOS

Transactions, American Geophysical Union

The Weekly Newspaper of Geophysics

For speedier treatment of contributions send three copies of the double-spaced manuscript to one of the editors named below and one copy to AGU.

Editor-in-Chief: A. F. Spilhaus, Jr.; Editors: Marcel Ackerman, Mary P. Anderson, Peter M. Bell (News), Bruce Doe, C. Stewart Gillmor (History), Clyde C. Goad, Arnold L. Gordon, Louis J. Lanzerotti, Robert A. Phinney; Managing Editor: Gregg Forte; Editorial Assistant: Kathleen M. Lafferty; News Writer: Barbara T. Richman; News Intern: Bohdan Dowhaluk; Production Staff: James M. Hebblethwaite, Dae Sung Kim, Patricia Lichiello, Lisa Lichtenstein, Cynthia T. McManigal.

Officers of the Union
James A. Van Allen, President; Charles L. Drake, President-Elect; Leslie H. Meredith, General Secretary; Carl Kisslinger, Foreign Secretary; A. F. Spilhaus, Jr., Executive Director; Waldo E. Smith, Executive Director Emeritus.

For advertising information, contact Robin E. Little, advertising coordinator, toll free at 800-424-2488 or, in the D.C. area, 462-6903.

Subscription price to members is included in annual dues ($20.00 per year). Information on institutional subscriptions is available on request. Second-class postage paid at Washington, D. C., and at additional mailing offices. *Eos, Transactions, American Geophysical Union* (ISSN 0096-3941) is published weekly by

American Geophysical Union
2000 Florida Avenue, N.W.
Washington, D. C. 20009

Cover. Sea MARC 1 side-scan acoustic image of the summit of MOK Seamount (09°57'N/104°34'W). Side-scan vehicle path is along the midline of the image. White areas show strongest acoustic returns, while dark areas are in acoustic shadow. Summit caldera is the most prominent feature and consists of three coalesced craters; the southeastern one is the deepest (380 m). Grooved terrain along the left side of the photo reflects the gullied edge of the summit plateau created by mass wasting of the upper flank of the edifice. A small, 20-m high cratered cone east of the deepest crater has produced a 2-km-long lava tube that winds across the summit plateau (see article, p. 482).

Diamonds and Carbon Isotopes

Diamond crystals may contain useful geochemical evidence of the deep portions of the upper mantle in their carbon isotopes. Two recent studies of types I and II diamonds showed that variations in $\delta^{13}C$ may be related to carbon reservoir sources in the mantle (*Nature, 303*, 791–792, and 793–795, 1983). In the case of type II diamonds, it was noted that there is a strong—although not total—correlation with eclogitic suites. Type II diamonds are low in nitrogen content, which would be consistent with aluminum in their eclogitic inclusions having acted as a nitrogen getter. The range in $\delta^{13}C$ values was -0.5 to -31.9‰, which actually is broad enough to include the variations of all known diamonds. With regard to individual crystals, however, it was confirmed that, on average, type II diamonds are isotopically lighter than type I. It is suggested that type II diamonds are a sampling of an open carbon isotope reservoir, with minimal evidence of fractionation. The variability may reflect the influences of recycled crustal material that reacted in the mantle.

In the study of type I diamonds, the crystals were precisely dissected by laser beam. The sections were analyzed to determine zoning effects within single crystals. It was found that there was a trend from core to exterior. In some samples, the cores were isotopically light (enriched in ^{12}C), and the edges were progressively heavier. A regular pattern, it was suggested, may have been due to a Rayleigh distillation process or diffusion, but from a single reservoir. Many of the specimens were isotopically heterogeneous, even on a fine scale, which may indicate a multiple fractionation process. Variations were found within rectangular growth zones, indicating that there may have been random fluctuations in the isotope fractionation process, superimposed on an underlying trend of core to exterior.

The method of dissecting diamond crystals was to use a focused, Q-switched, Nd-YAG laser; it was the first attempt to use this method for selecting samples of a single crystal for later stable isotope analysis.—*PMB*

Waterman Award

Nominations are being accepted for the Alan T. Waterman Award, which annually recognizes an outstanding young scientist in the forefront of science. The award, named for the first director of the National Science Foundation, was established by Congress 8 years ago to mark the agency's silver anniversary.

Candidates must be U.S. citizens and must be 35 years old or younger (or not be more than 5 years beyond receipt of the Ph.D. degree by December 31 of the year in which nominated). Candidates should have completed sufficient scientific or engineering research to have demonstrated through personal accomplishments outstanding capability and exceptional promise for significant future achievement, the award committee says. In addition, those nominated should exhibit quality, innovation, and potential for discovery in their research.

In addition to a medal and other recognition, the recipient receives a grant of up to $50,000 per year for up to 3 years for scientific research or advanced study in the physical, biological, mathematical, medical, engineering, social, or other sciences at the institution of the recipient's choice.

Nominations should be submitted to the Alan T. Waterman Award Committee, National Science Foundation, Washington, DC 20550. Additional information and nomination forms may be obtained from Lois J. Hamaty, Executive Secretary (telephone: 202-357-7512). The award is announced every May. For candidates to be considered for the 1984 award, nominations must be received by December 31, 1983.

Space Stations Favored

Recently, Presidential Science Advisor George A. Keyworth II created a new wave of enthusiasm about the future of the U.S. space program by stating in *Science* magazine that the National Aeronautics and Space Administration (NASA) should consider a major new initiative (July 8, 1983). Keyworth has previously used *Science* magazine to provide his views on policy to the science community; in the past the messages have not been so supportive of the space program, but apparently NASA has made the case for an ambitious plan of space technology and development. The new program may involve space stations to support a colony on the moon (see *Eos*, April 19, 1983, p. 145) and perhaps Mars.

In the July 8 *Science*, Keyworth is quoted as saying, "I think the country would take a major thrust in space very seriously. We've shown that the shuttle works, and is realistic. We know we have the technology to build a space station—most advocates of a space station readily acknowledge that it is only an intermediate step in a more ambitious long-range goal of exploring the solar system."

One approach is to construct a transfer system between low earth orbit and geosynchronous orbit. Such a system would save fuel throughout the program; it would also permit shutting of men and material to the moon for construction of an expanded base of operations. The main concept here is that space stations are laboratories in themselves, as well as being way points or platforms to serve as a step in extended transportation plans.

NASA plans to propose construction of a space laboratory in the next fiscal year budget. These plans have existed for some time, as a logical component of the space shuttle program. The space lab could be designed as a base for earth orbital operations that may lead to the development of factories on the moon and extended missions to Mars.—*PMB*

Radioactivity in Urals

Interest in the problems due to the radioactive contamination of the environment has been frequently stimulated by rumors of an occurrence of severe contamination of lakes and rivers in areas of the Ural Mountains. Occasional evidence appearing in publications and provided by Soviet emigrants has been pieced together and seems to suggest that there is an ideal opportunity for groundwater geochemists and others to evaluate such major radioactivity in the environment. The reasons that such a study probably will not take place is that the contamination may have been caused for the most part by a nuclear explosion in a Soviet weapons plant.

F. Parker, an environmental scientist at Vanderbilt University, in a study for the Department of Energy, deduced that a large explosion occurred in 1958 at a nuclear fuels reprocessing plant at Kyshtym in the Ural Mountains, according to a recent report (*Science*, July 8, 1983). The report refers to the original interpretations of Z. Medvedev, a Soviet geneticist, who concluded that nuclear fallout has contaminated a very extensive area around Kyshtym.

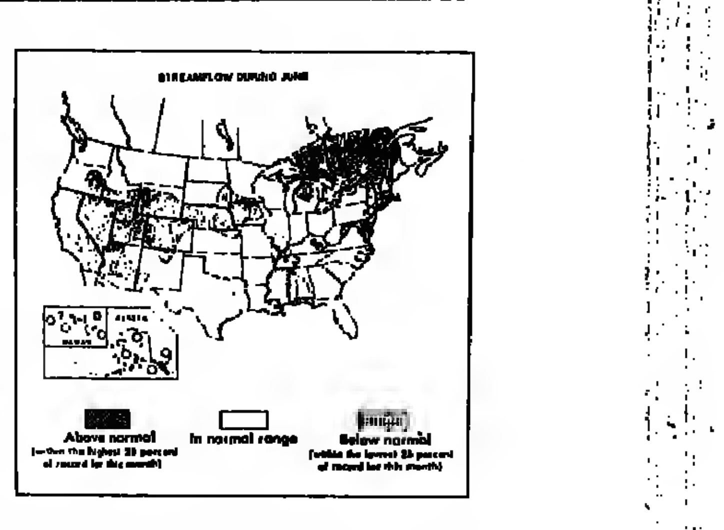
Parker described the interesting story, obtained from his interviews with Soviet emigrants, that the Soviets have duplicated, down to intricate detail, a U.S. weapons plant located in Richland, Washington. Evidently, the Urals' version of the plant did not have adequate environmental protection and safety procedures. The report stated: "The Soviet engineer (an emigrant) said that there had been many mishaps at Kyshtym that resulted in extensive contamination of the Techa River and its surroundings." Radioactive materials seemed to have been spilled frequently. The explosion incident described by Medvedev appears to have been confirmed through eye-witness accounts. The resulting contamination was so great that a large group of inhabitants, about 10,000 people, were evacuated from the area. The area may be good for geochemical study for some time to come.
—*PMB*

June Streamflow

More than 90% of the key index gaging stations across the country reported average to well-above average streamflows in June, and record-high flows were set on streams in Mississippi, Kansas, Nevada, and California, according to a month-end summary of water-resources conditions by the U.S. Geological Survey (USGS).

USGS hydrologists said that the unusually wet conditions were also evident in the combined flow of the three largest rivers in the lower 48 states—the Mississippi, St. Lawrence, and Columbia rivers—which averaged 5841 billion liters per day (bld) (1,208 billion gallons per day) during June, 49% above the long-term average. The combined flow of these major rivers has been above average now for 16 of the past 17 months. These three large river systems, which include the flow of the Missouri and Ohio rivers, account for runoff from more than half of the conterminous United States and provide a quick check on the status of the nation's surface-water resources.

Only 14 (or 8%) of the 173 key index gaging stations reported below-average flows during June. The below-average flows were reported at individual stations in Florida, Georgia, South Carolina, Indiana, and Wisconsin in the eastern half of the country and in a regional band across the Northwest. Well-above average flows were reported by 70 stations.



At the end of June the Great Salt Lake, which had been rising steadily over the past 10 months, reached a high point for the year of 1281.68 m above sea level. This is the highest annual peak since 1924 when the lake rose 1281.71 m. The highest recorded level was set in 1873 at about 1283.66 m. The lake rose 1.58 m from September 15, 1982, to June 30, 1983, the greatest seasonal rise ever recorded, topping the previous record of 1.04 m for the same period in 1906–07.

The record snowmelt runoff from the heavy snow accumulations in the western states pushed 11 major streams to record high flows at USGS gaging stations in Arizona, California, Colorado, Nevada, Utah, and Wyoming. The severe snowmelt flooding produced 100-year flows along portions of the Colorado River. The gaging station on the Colorado River along the Colorado-Utah border reported a peak flow of 189 bld on June 26. Flows of this magnitude are not expected to occur on the long-term average of more than once in a hundred years. Melting snowpack also contributed to extensive flooding in Nebraska along the North Platte River.

In the lower Mississippi River basin, flow of the Mississippi River at Vicksburg, Miss., set a new daily high flow on June 4 of 5130 bld. For the month, flow of the Mississippi at the gaging station averaged 3622 bld, 136% above average and the second highest June flow in 54 years of record. Elsewhere in the Mississippi basin, a record daily flow was set on the Big Black River near Bovina, Miss. In Louisiana, the flow of the Pearl River near Bogalusa set a record for the month, averaging 70.6 bld, the highest June flow in 45 years of record.

Record or near-record high groundwater levels at individual wells in several states, including California, New York, Massachusetts, and Maine, also indicate the generally wet conditions throughout the country. The water level in one well at Granville, Mass., west of Springfield, stood at 8.55 m below the land surface, the highest level ever recorded in this well in almost 20 years of record.

Flows of the "Big Five" rivers were as follows: Mississippi River at Vicksburg, Miss., 3622 bld, 136% above average for June, but down seasonally by 22% from May; Columbia River at the Dalles, Ore., 1354 bld, 3% less than the June average, but up 12% from last month; St. Lawrence River near Massena, N.Y., 864 bld, 6% above average for June and 6% above May's flow; Missouri River at Hermann, Mo., 441 bld, 76% above average for June, but down 27% from the previous month; and Ohio River at Louisville, Ky., 243 bld, 33% above the June average, but 75% below May's flow. (Map courtesy of the U.S. Geological Survey.)

Geophysicists

Homer E. Newell, president of AGU from 1970 to 1972, died July 18. He was 68 years old. In 1962, he and James A. Van Allen, current AGU President, worked together to start AGU's Planetary Sciences Section. Newell was the section's first president (1962–1964). In 1958, after 15 years at the Naval Research Laboratory, where he headed the program on rocket research in the upper atmosphere, Newell became assistant director for space sciences at the newly formed National Aeronautics and Space Administration (NASA). Two years later he was appointed deputy director for space flight programs. In 1963 he was appointed director of the Office of Space Sciences, and 4 years after that he became NASA's associate administrator. An AGU Life Member, Newell joined AGU in 1949.

Homer E. Newell

Article *(cont. from p. 481)*

ratus sufficient to plan, conduct, and finance several very large field experiments. The final tangible products of the observations, including a complete year of global data, will be available in late 1983.

The meteorology of the polar regions is more and more becoming the locus of global atmospheric problems. The sensitivity of the climate operating through the radiation balance, including the effects of clouds and arctic haze, remains a central issue. In addition, the chemistry of the polar atmosphere, particularly the presence and distribution of certain trace substances, is a new feature of the meteorology of high latitudes.

Finally, a comment about the hazards and joys of editing. Several authors affirmed that my editorial suggestions improved their papers; the rest were courteous enough to remain silent. I am grateful to both.

References

Cicerone, R. J., Halogens in the atmosphere, *Rev. Geophys. Space Phys.*, 19, 123–139, 1981.

Duce, R. A., V. A. Mohnen, P. R. Zimmerman, D. Grosjean, W. Cautreels, R. Chatfield, R. Jaenicke, J. A. Ogren, E. D. Pellizzari, and G. T. Wallace, Organic material in the global troposphere, *Rev. Geophys. Space Phys.*, in press.

Graedel, T. E. and C. J. Weschler, Chemistry within aqueous atmospheric aerosols and raindrops, *Rev. Geophys. Space Phys.*, 19, 505–539, 1981.

Logan, J. A., Nitrogen oxides in the troposphere: Global and regional budgets, *Adv. in Chem.*, submitted for publication.

Logan J. A., M. J. Prather, S. C. Wofsy, and M. B. McElroy, Tropospheric chemistry: A global perspective, *J. Geophys. Res.*, 86 (C8), 7210–7254, 1981.

Prospero, J., V. Mohnen, R. Jaenicke, R. J. Charlson, A. C. Delany, J. Moyers, W. Zoller, and K. Rahan, Atmospheric aerosols; cycles and measurements, *Rev. Geophys. Space Phys.*, in press.

Contents: IUGG Quadrennial Report
Meteorology

Geomagnetism and Paleomagnetism 1979–1983

M. Fuller
Department of Geological Sciences, University of California, Santa Barbara, CA 93106

My function, in writing these notes, is to bring you up to date in Geomagnetism and Paleomagnetism, in as painless a manner as possible—without tears, as the French language texts for tourists used to promise. In writing this account of progress in the past quadrennium, I must first acknowledge that it is a personal and subjective viewpoint; another reporter would surely emphasize other developments. Yet, there is some virtue in writing of things about which one knows something, so I leave to future reporters the task of redressing the balance in matters covered.

At the outset, one very sad event must be recorded. On April 3, 1981, Sir Edward Bullard died. His published work alone marks him as one of the leaders of geomagnetism in our times. Yet his contribution was much greater; many an American geophysicist, as well as a whole generation of British colleagues, have felt the benefit of his perceptive advice on their research. To those who saw him in the last few months of his life, his courage in the face of his illness was a remarkable example of fortitude. It is by now well known that the definitive paper, which he wrote with Malin, on secular variation at London, was only completed immediately before his death. The transmittal letter had been typed, but death prevented him from signing it. Bullard returned in this final paper to a topic to which he had contributed much. In it, he notes the role of Halley, who first described the phenomenon of westward drift, to which Bullard gave a new numerical precision, two and a half centuries later. I seem to remember Bullard saying in a lecture years ago that, while the Newtons of this world seem other than mortal, Halley was a scientist whose life and acheivements could encourage one's own efforts. Bullard, like Halley, inspires and encourages us.

The past four years have been a time of considerable progress and excitement in geomagnetism and paleomagnetism. One of the highlights was MAGSAT. During its seven months in orbit, it completed the first global vector magnetic survey. The resulting data were used heavily in the 1980 IGRF, which was probably the most accurate ever compiled. The contribution of MAGSAT extended however far beyond this; it provided new knowledge of the external field, the core field and of crustal anomalies. The analysis of data is still underway, but already it has confirmed the predicted importance of vector data suggested by Backus. Indeed, a number of studies have appeared in the quadrennium, whose principal aim has been better field representation; Langel and co-workers have taken account of the local anomaly fields at observatories to obtain better raw main field data, Shure and others have used harmonic splines to produce models that are smooth on the core mantle boundary, and Harrison has drawn attention to the important implications for field representation of the trigonometric form of the spherical harmonics.

Secular variation studies have not benefited from MAGSAT, as much as main field studies. Only after a number of low orbit satellites will it be possible to improve secular variation models comparably. Meanwhile difficulties in predicting secular variation persist. Controversy has developed over possible rapid changes or "jerks" in the field values. It is argued by some, as Alldredge describes below, that the rapid changes may be the result of inadequate analysis. Others correlate the features with changes in the length of the day to infer aspects of core mantle coupling. If the rapid changes do stand the test of further analysis, they could provide important data for the conductivity of the lower mantle, and we shall have to revive our ideas on the time scale of changes in the core field that are observable on the earth's surface.

Paleomagnetists and archaeomagnetists continue their efforts to use remanent magnetism of rocks and archaeological material to extend the detailed history of the field back from hundreds to a few thousand years. The principal aim is to understand secular variation in terms of such proposed phenomena as dipole wobble, dipole intensity fluctuations, and changes in non-dipole features, supposed to arise from core mantle sources.

Archaeomagnetism affords a link between the secular variation records obtained from modern observatories and obtained those from paleomagnetism. The quadrennium was marked by the long awaited publication of the French archaeomagnetic curves by Prof. Thellier. The accumulation of data has led to new syntheses and to an increased recognition of the possible importance of dipole wobble. Champion has analyzed the available archaeomagnetic data and concludes that much of the directional data can be explained by dipole wobble. The same conclusion was reached earlier by Lin in Beijing, but the result was not generally known. This suggestion may not yet be on an appropriate statistical footing, but it does appear that dipole wobble has been underestimated in the past.

One approach to the description of paleosecular variation has been to make use of the excellent recording capabilities of lavas. Sufficient accurate spot readings of the field are made to determine the distribution of vectors at a site for a particular time interval. Models of secular variation, consisting of mixes of the proposed mechanisms, can then be tested in terms of predicted latitudinal dependence of the distributions of vectors. In the past quadrennium, Dodson was able to show, using this type of analysis on the large data sets available from Iceland, the Canaries, and Hawaii, that the core mantle sources must be biased to high latitudes.

The past four years have seen a resurgence of attempts to establish continuous records of secular variation. The principal work has been on lake sediments because they have the necessary rapid sedimentation rates. Patterns are beginning to emerge from correlations between different lakes, but correlations within particular lakes are still a good deal more convincing than those between different lakes. Eventually, it may prove possible to track individual nondipole anomalies, as one tracks meteorological features, but it remains to be demonstrated that the magnetic anomalies retain their identity while drifting. An encouraging aspect in the past quadrennium has been the increased sophistication of the data analysis.

As one passes to longer period aspects of the geomagnetic field, we encounter another area of considerable effort. Led by Wilson's studies of the offset dipole, Merrill and McElhinny have established that there are indeed long-term asymmetries of the geomagnetic field. For example, the sign of the ratio of g_2^0/g_1^0 is preserved during different polarity epochs. The evidence for the sign of g_3^0/g_1^0 is less clear. Nevertheless the possibility of persistent, or quasipersistent, nondipole aspects of the field are important, both to those who seek to understand the origin of the field and those who use it for tectonic reconstructions.

There have been a number of claims that short period intensity fluctuations of the field on a time scale as short as one hundred years may be substantial. Comprehensive studies of intensity data by McElhinny, Senanayake, and McFadden have shown that the distribution of values is best fitted by a truncated Gaussian distribution. This shows that the field does not follow a simple sinusoidal fluctuation. It is however consistent with aperiodic fluctuations, with both the nondipole and dipole fields varying in a correlated manner, i.e. when the dipole is strong, so is the nondipole field. This type of fluctuation is different from the variation we observe at present, when as the dipole field decreases, the nondipole field increases.

Studies of reversals, which were previously more concerned with recurrence intervals, have in the last four years moved towards detailed studies of individual reversals to determine the transition fields. The principal difficulty in the work is that we do not often have multiple records of an individual reversal, so that one faces the problem of a one point spherical harmonic analysis of the transitional field. Bearing in mind that the reversals may look very different, depending upon the latitude of the site at which they are observed, the major features are established and agreed upon. The change in direction takes a few thousand years, while an associated decrease in intensity to a value of less than about 10% of the initial field value takes about 10,000 years. The studies of transition fields has led, through the work of Hoffman, to a systematics that may eventually permit distinction between dominantly quadrupolar or octupolar fields.

One of the major features of the reversal work in the quadrennium has been a great increase in the number of reversal records. Although the systematics have been able to accommodate much of the new data, there are exceptions, so that it must be concluded that there are important differences in the transition fields for different reversals; they cannot all have the same geometry. Moreover, some reversals have important nonaxial field components. One wonders at this stage whether additional records will bring about what Bullard sometimes called the usual chaos of the earth sciences, or whether some aspects of the simple pattern will remain. When one considers the difficulty of obtaining reliable records, it is probably still a good bet that some of the axisymmetric simplicity is real and that some records are noisy.

The origin of the geomagnetic field remains a mystery. There is no argument that some sort of dynamo in the outer core is responsible for it, but there is little agreement as to which sort it is. One is reminded of Elsasser's warning that the core may not reveal the details of its motions to our analysis. To an outsider, it appears that dynamo theorists, while not totally foregoing the more baroque pleasures of theorem and countertheorem, are taking a closer look at the physical state of the core and at the record of the geomagnetic field, to produce more physically realistic models. One thinks of the work by Busse, with its experimental and theoretical analysis of the importance of the Taylor columns dividing the outer core and Loper's dynamo driven by the progressive freezing of the inner core.

The Faraday disc dynamo, a particularly simple model of the geomagnetic dynamo process, continues to give interesting results; the analysis of Robbins showed that, by adding a shunt to the circuit, the simulation of the paleomagnetic field record is remarkable. The behavior is replete with intensity fluctuations and reversals with irregular recurrence rates. The turbulent dynamo approach with its separation of the dynamo processes into two scale sizes, the smaller of which can be sampled statistically continues to prove its power, as described in more detail by Benton below. The use of the frozen field approximation holds promise for a more detailed understanding of reversals and secular variation. The approach assumes that field lines move with the fluid in the core. A consequence is that null flux lines, that enclose fluid above which there is no radial component, must remain null flux lines; they can be deformed but reconnection, which requires diffusion, is not allowed. This approach may well place constraints on the transition fields during reversals, providing that the scale size of the important features is large enough that the approximation is relevant. As Benton points out, the idea of null flux lines has recently been given fresh impetus by Hide, who has shown how it can be used to place estimates of the depth to the core-mantle boundary. On earth, this can, of course, be checked against the seismological results, and the method has been vindicated. The method may also be applied to planets such as Jupiter for which the depth to the surface of the magnetic field generating region is not known.

Rock magnetism continues to make progress, but fundamental problems are unsolved and the topic, like dynamo theory, remains inherently difficult. One seeks to understand structure sensitive properties of an ensemble of particles, whose state of internal stress and composition is poorly known. These phases are a far cry from the well-documented single crystals, most often studied in solid state physics laboratories. At the risk of using this report to further personal prejudices, it does seem to this reporter that we may be approaching answers to some fundamental questions in rock magnetism because we are recognizing the importance of departures from equilibrium configurations. In particular, as Halgedahl has shown, pseudo-single domain behavior may be a consequence of domain wall nucleation phenomena. Thus particles that can sustain a domain wall may be indefinitely preserved in a metastable, no wall, or single domain state because they are unable to nucleate a wall. As the grain size increases from the true single domain range, the probability of activation of nucleation sites increases to give walls in some magnetization states. Eventually, with further increase of grain size the nucleation sites are numerous enough to ensure multidomain behavior. Thus there is a gradual transition, the pseudosingle domain state, from true single domain to true multidomain. If these ideas stand the test of further work, the old paradox of the success of Neel's single domain model of thermoremanent magnetization will finally be resolved; the magnetic particles in rocks are indeed too large to be single domain but there are enough of them in a metastable single domain state to account for thermoremanence.

Thermoremanent magnetization remains an area of considerable activity, as is appropriate, for the principal magnetization mechanism of the paleomagnetic record. Studies of the variation of the blocking temperature with ambient field by Sugiura and by Clauter and Schmidt have revealed the way in which the increased field decreases the blocking temperature. Merrill has pointed out shortcomings in our use of the simple geomagnetic demagnetizing factor. A number of groups in Canada, the United Kingdom, and the United States have started to investigate the effect of cooling rate on thermoremanent magnetization and have recognized again the importance of modeling the approach to equilibrium.

The interpretation of the magnetizaton of the sea floor has continued to occupy the efforts of many workers. There is a growing recognition that the layer 2b intrusive rocks may be of greater importance than had been previously recognized. The details of the processes of low temperature oxidation and the role of hydrothermal fluids in modifying the magnetic record of the sea floor are other active areas, which remain to be resolved.

With the increasing sensitivity of the various magnetometers available to paleomagnetists, the rock magnetism of sedimentary rocks is once again coming to the forefront. The process of acquisition of post depositional remanence has been studied by drying sediments, while observing their remanent magnetization. Models of the blocking process of considerable promise have emerged. Much of the controversy about the magnetization of sediments is still centered upon the time lag between sedimentation and the acquisition of remanent magnetization. The review of chemical remanent magnetization by Merrill and Henshaw is of relevance here, as is the documentation, by Larson, of cases in which the magnetism of redbeds was acquired long after formation. Clearly the use of redbeds in high resolution magnetostratigraphy must be accompanied by a demonstration of the time of acquisition of remanence.

One of the most remarkable developments of the past few years has been the improvement in the techniques and instrumentation of paleomagnetism. The sensitivity and fast response time of the SQUID magnetometers have brought about a revolution in measurement. Moreover, at just the right time, the microcomputer revolution has come along; it has permitted the full power of the instruments to be utilized. It is now commonplace for each magnetometer in a laboratory to have its own microcomputer, provided with on line Zijderveld diagrams and stereoplots. Thus, not only has the sensitivity of the SQUID's made possible the use of samples, which would have been regarded as useless ten years ago, but the analysis of data sets is now far more sophisticated; one can analyze different components of magnetiziation in a manner impracticable before the SQUIDS and micros. To an old relic of the astatic magnetometer era—the capabilities are amazing, but so too is the next level of complexity revealed in nature.

Without much doubt the principal contribution of paleomagnetism to the earth sciences has been the part it placed in ushering in the new mobilist view of tectonics, through its demonstration of continental drift and the interpretation of the seafloor anomalies. The seafloor anomalies continue to play a key role in the interpretation of the tectonics of the past 100 million years. Recently, important clarifications of the Atlantic and Indian oceans have appeared. Much effort is now involved in the interpretation of the more puzzling anomalies, in back arc basins, where the record is less clearly written and the tectonic process more complicated. In a similar manner, continental paleomagnetism has by now established the major features of the history of most of the larger continental blocks for the past 100 million years. The most difficult problems of Paleozoic and PreCambrian reconstructions and the history of microplates and other crustal fragments caught in evolving plate margins are now the focus of interest.

PreCambrian paleomagnetic reconstructions are principally concerned with whether there was single supercontinent or whether there were several landmasses. Such questions have important bearing for the tectonic style in the PreCambrian. Were, plate motions, as we know them, an aspect of the PreCambrian scene? They also bear upon the interpretation of early "faunal" provinces. A prerequisite for successful PreCambrain paleomagnetism is to be able to track apparent polar wander paths back from Phanerozoic reconstructions to the PreCambrian, knowing which pole one is determining. The principal hope is that certain section will indeed carry us safely back to the PreCambrian with enough detail to resolve the polarity ambiguity. Until this is done reconstructions face insurmountable difficulties.

The principal recent advance in paleomagnetic studies applied to tectonics has been in the studies of microplates and fragments of plates caught in evolving plate margins. Although there had been antecedents of such work, the recent activity is on a totally new scale. The western regions of North America are being so depleted by the drilling of the paleomagnetists that one fears for an isostatic rebound. The essence of the results is that numerous small units, christened terranes, have moved northward over periods of millions of years in a process somewhat analogous to a gigantic long shore drift. It is the paleomagnetic inclination, which reveals that the terranes must have come from far south. They became attached to the North American landmass and subsequently were tectonically deformed, disrupted, and transported northward. The process may sometimes have been related to oblique subduction, but other times it seems to have involved plate fragmentation rather than classical plate tectonic mechanisms. Among the many groups involved in the documentation of the history of the various parts of this western margin of the North American landmass are Beck at West Washington State University, Hillhouse and others at the USGS at Menlo Park, Cox and others at Stanford, Stone at the University of Alaska, Luyendyk and his group at UCSB, and Marshall at San Diego State University.

Paleomagnetism has also been able to contribute to geology by helping to establish the time scale. The seafloor reversal record contains an incredible wealth of stratigraphic information, and considerable effort has now gone into establishing this chronology on land, in paleontologically datable material. One of the most successful studies was that in the Gubbio section of northern Italy by Lowrie, Alvarez, and others. Here the Late Cretaceous and Early Tertiary magnetostratigraphy have been established in detail. It has been most rewarding to watch the continental record emerge and to see it match the seafloor data. A similar effort has of course been going on for sometime in the Deep Sea Drilling cores. This has proved difficult, although the advent of the giant piston corer may well revolutionize this work. A revised time scale has been published by Ness and others, which continues the process of dating absolutely the principal stratigraphic boundaries of the past 100 million years. This chronology can then be used in applications, as varied as the timing of tectonic rotations and the dating of hominid finds.

The study of continental magnetic anomalies in the United States has benefited from the appearance of the National Magnetic Anomaly Map. The map suffers from the difficulty of being a patchwork of data gathered from different altitudes and with different line spacings, but it is a first step. Hinze is to be congratulated on the successful completion of the difficult task of obtaining the necessary data and seeing the map through the various committees to publication. It must also be a great satisfaction for Zeitz to see this expression of his earlier compilation efforts. It is now to be hoped that the United States will join other nations, developed and developing, which have an aeromagnetic map of their country on a common data base.

The availability of the National Magnetic Anomaly Map and the MAGSAT maps encourages tectonocists to analyze the magnetic data. Already considerable discussion of the long wavelength anomalies has begun. The reality of some aspects of these features is still in dispute, but that such features exist seems inescapable. The Curie point isotherm may indeed give such a long wavelength source. Recently, Wasilewski has, however, suggested that the Moho may be a magnetic boundary, with no magnetic signal coming from mantle sources. It is not yet clear whether this is the case or whether the Curie point isotherm will be the critical boundary. At the opposite extreme of magnetic anomaly work, there is increased activity in determining very small anomalies in sedimentary basins. The availability of the SQUID gradiometers may yet give rise to a new round of high precision surveys.

Observations of temporal changes in the geomagnetic field as a precursor of earthquake and volcanic activity have long attracted workers. Unfortunately, the subject has suffered in the past from too much modeling and too little observation. The early models had uncertainties of roughly an order of magnitude in each of the several parameters required to calculate the stress response of unknown rocks, at an unknown depth to unknown stress. However, models predicted effects within an order of magnitude of the capabilities of instrumentation at the time. Recendy, after a considerable improvement in technique has shown little indication of the proposed effects, the models have been revised downwards by about an order of magnitude to the new detection limit, although the unknowns remain about as unknown as before. Meanwhile attempts to observe the effects continue. Both the instruments themselves and the data analysis have been upgraded as described by Davis below. The experiment is extremely difficult, and one must admit that a clear demonstration of the seismomagnetic effect is still awaited.

The volcanomagnetic effect has been more convincingly demonstrated. Davis has reported events from both Kilauea and St. Helens and Johnston another event from St. Helens. Like observation of the seismomagnetic effect, its observation requires high sensitivity instruments coupled with analysis that can eliminate the background noise orders of magnitude larger than the signal. In the experiments one seeks to determine fractional gamma anomalies with time constant of weeks, or months!

In the past four years, a wealth of electromagnetic studies have emerged. To the outsider there is a bewildering number of techniques involved, but there is no doubt that these methods are now giving important information about the crust and upper mantle. In major zones of crustal extension there is a ubiquitous low electrical resistence anomaly that accompanies the decrease in P-wave velocity. Below this, there is a region of normal crust of a few tens of kilometers and then the mantle itself is found to have anomalously low seismic velocity, density, and electrical resistance. Anomalous conductors have also been found over subduction zones, at depths of nearly 20 kms. It remains to be seen whether this is due to rising magma or to the presence of water. The intrinsically difficult problem of electromagnetic measurements on the seafloor continues to attract attention; active source techniques are used to resolve shallow structure and MT and geomagnetic variations to resolve the features deeper than 20 kms. Filloux has shown that at 12° and 21°N on the East Pacific Rise there is a conductor about 30 kms below a resistive layer. Beneath a site in the fore arc of the Marianas, Filloux interprets a shallow conducting layer which he ascribes to the sediments and, below them, a thick resistive crust and asthenusphere. These studies continue to be supported by laboratory studies that give better estimates of the electrical properties of minerals in the relevant environment at depth and by continually improving techniques of analysis.

The paleomagnetism of extra-terrestrial material has taxed our capabilities to the limit. There is little disagreement that meteorites and lunar samples have some remanent magnetization, which was acquired before they arrived on earth. There is also substantial agreement that some meteorites and some lunar samples were magnetized in relatively strong magnetic fields—comparable in order of magnitude to the earth's field. Surface magnetometers, orbiting magnetometers, and the orbital electron back scattering experiment all demonstrate that the moon's crust is magnetized in a patchy manner. These matters are discussed in detail by Hood and Cisowski. Suggested explanations of lunar magnetism have included random moments in the rocks, impact related effects, a lunar dynamo, a fossil magnetism inherited from the moon's formation and the geomagnetic field. Recently Cisowski has analyzed in detail the relationship between the strength magnetization and the age of the lunar samples. He has shown that the strongly magnetized samples have a very restricted age range of between 3.6 and 3.8 AE. This casts a new light on lunar magnetism. For example, shock fails as an explanation for lunar magnetism because there is no reason why shock effects would only occur in such a limited period of time. It is curious that this period coincides with the end of the major bombardment of the moon and the onset of mare basalt extrusion; Cisowski speculates that there may be some common cause, the most natural of which is the close approach of the moon to the earth. Even in this circumstance, some amplification of the geomagnetic field would be required, before it could account for the postulated lunar fields, unless the terrestrial field was larger by more than an order of magnitude at that time. The magnetism of meteorites, like that of the lunar samples is inadequately documented and the subject of considerable controversy. Very large inducing fields of the order of oersteds are claimed for the early solar system. However, it is still too early to have very much confidence in these results. When one considers that much of the magnetization of the lunar samples and of the meteorites was probably acquired nearly 4 AE ago, the luxury of a few more years to interpret this magnetism does not seem unreasonable. Meanwhile, the magnetic properties can be used to define classification schemes of meteorites comparable to those usually based upon their chemistry. All in all, the past four years have seen considerable progress in this area of paleomagnetism.

The quadrennium has seen, if not the birth of a new science, at least the emergence into respectability of a new aspect of geomagnedam, biomagnetism. Biomagnetism itself is a field with a considerable literature, including innumerable attempts to document the effect of magnetic fields on the growth of cells and, in particular, on tumors. The particular branch of biomagnetism, which is most immediately relevant to geomagnetism, is the use of the geomagnetic field by various organisms to navigate, or to regulate aspects of their physiology.

It is well known that animals are able to navigate over long distances. It has been shown that disruption of the "magnetic sense" of pigeons, by placing μ-metol sheilds over their heads, has no effect on their navigation on sunny days, but on overcast days it severely reduces their navigational capabilities. They evidently have a sun-orienting system, with a backup system utilizing a magnetostatic or electromagnetic effect. The most direct example of a magnetostatic system is that found in certain bottom-seeking bacteria that contain strings of magnetite particles. The torque on such a string of interacting single domain particles is potent in the world of a bacterium. Indeed the efficacy of the system can be demonstrated on a microscope slide. In the presence of a field, northern hemisphere bacteria swim, as a mass, along the field lines towards the south magnetic pole. On switching the polarity of the field, the bacteria reverse their direction.

The mechanism of field detection is not clearly demonstrated in higher animals. Indeed, no convincing explanation of a purely magnetostatic detection system has appeared. However, it has been demonstrated that certain fish are able to detect the very weak electric currents generated by their prey. By extension, Kalmijn argues that they can also detect the weak currents which flow through their bodies as a result of the Lorentz force caused by motion in the geomagnetic field. That many animals contain magnetite is now irrefutable and the list grows rapidly, e.g. tuna, bees, pigeons, whales, dolphins, turtles, and stingrays. A path of synthesis has been demonstrated by Lowenstam working on chiton. What has so far eluded workers is the manner in which the magnetite is used in a detection system. Kirschvink has pointed out that magnetite has the curious combination of being a strong ferrite, which is also a good electrical conductor, and suggests that a possible mechanism would be the rotation of particlea of magnetite to short out a nerve path. Recently workers at the Massachusetts Institute of Technology and the State University of New York at Stonybrook have shown that iron particles are in specialized cells around the abdomen of bees that have a plentiful nerve supply. Such an identification of specialized cells in an organism, which is known to sense the field, may be the beginning of the final recognition of the detectors.

This review of activity of geomagnetism and paleomagnetism will, I hope, have stimulated the reader to delve deeper in the specialized reviews, which follow. There seems little doubt that the subject is alive and well. The efforts of a large number of research workers are involved, and the pace of research progress is unlikely to slacken, unless the necessary funding support is lost. In the forthcoming quadrennium we can look forward to better documentation of the main field and its history. The paleomagnetic records of secular variation and reversals should be substantially improved and may provide critical clues to the dynamo problem. Meanwhile, the new paleomagnetism of the plate margins should help us to understand how continents are formed and grow. The continuing analysis of the MAGSAT data will surely help us understand the deep structure of the crust. Finally, there is little doubt that biomagnetism will flourish; we may even have the beginnings of an understanding of a new sense. In short, the next quadrennium promises to be a most interesting one, with plenty to keep us busy.

Contents: IUGG Quadrennial Report
Geomagnetism and Paleomagnetism

Books

Geothermal Reservoir Engineering

M. A. Grant, I. G. Donaldson, and P. F. Bixley, Academic, New York, xiii + 369 pp., 1982.

Reviewed by James W. Mercer

The goal of the authors in writing *Geothermal Reservoir Engineering* was to bring together all the currently available information on geothermal reservoir engineering published before late 1981. The available information not only includes geothermal publications but also related publications in the areas of petroleum reservoir engineering and groundwater hydrology. Such a text would be a needed and worthwhile addition to many libraries, if the goal of the authors were achieved. Unfortunately, *Geothermal Reservoir Engineering* falls short of its potential contribution.

The book is divided into 10 chapters and three appendices, organized in a fashion similar to the logical steps one would take in characterizing a geothermal field. Chapter 1 consists of an introduction to the book and geothermal reservoirs in general. In chapter 2, conceptual models of geothermal fields and systems are presented. An attempt is made to explain complex processes in a simple manner. The conceptual models in chapter 2 are quantified, in part, in chapter 3, entitled, "Simple Quantitative Models." This chapter provides a good summary of lumped-parameter models. Chapter 4 is entitled "Well Completion and Warm-Up," and in chapter 5, flow testing is discussed, primarily in a qualitative way. No permeability calculations are made. A case study of a well in the Broadlands Geothermal Field, New Zealand, is presented in chapter 6. Chapters 7 and 8 contain descriptions of several different geothermal fields in various stages of development. Chapters 9 and 10 contain discussions on field monitoring and management and current geothermal reservoir problems, respectively. Problems discussed include flow in fractured media, reinjection, and subsidence. The appendices contain the quantitative meat of the book and should probably be read before the main body of the book. Pressure transient analysis is discussed in appendix 1, whereas the equations of motion and state are presented in appendix 2. Appendix 3 contains steam tables, conversions, and notations.

Contrary to what the book title suggests, details on how to measure and interpret data from geothermal reservoirs are not presented. A more appropriate title would have been "Introduction to Geothermal Development via Case Histories." Instead of providing a systematic approach to performing geothermal reservoir engineering, the authors provide a cursory, and often qualitative, introduction to various geothermal fields. Through these case histories, consisting in large part of New Zealand fields, the authors attempt to make various points. The presentation is often difficult to follow, and the points are sometimes missed. The transition from topic to topic is choppy, as if cutting and taping of many references was performed to string together a complete chapter. Where equations are given, a discussion of assumptions and limitations is often lacking. Therefore, the reader will have to refer to the original references in order to use some of the techniques presented.

Unfortunately, the literature reviews used to make up the chapters are incomplete. Not only were important references in hydrogeology and geothermal and petroleum reservoir engineering omitted, but no references were included from the related areas of aquifer thermal energy storage or high-level radioactive waste disposal. This latter topic is particularly relevant to the discussions on flow in fractured media. Many of the references included are difficult to obtain because they were published as reports by laboratories or government agencies, and no fewer than 12 unpublished reports are referenced.

A quantitative book on geothermal reservoir engineering that could be used as a tool for both the student and practicing engineer would have been a valuable contribution to the field. *Geothermal Reservoir Engineering* does not fill this need. The book cannot be used as a stand-alone tool and provides only a small extension to books and references that were previously available (notably those edited by Ryback and Muffler, and by Kestin, DiPippo, Khalifa, and Ryley).

James W. Mercer is with GeoTrans, Inc., Reston, VA 22090.

Multiobjective Decision Analysis With Engineering and Business Applications

A. Goicoechea, D. R. Hansen, and L. Duckstein, John Wiley, New York, xvii + 519 pp., 1982, $34.95.

Reviewed by Eric Wood

The last 15 years have witnessed the development of a large number of multiobjective decision techniques. Applying these techniques to environmental, engineering, and business problems has become well accepted. *Multiobjective Decision Analysis With Engineering and Business Applications* attempts to cover the main multiobjective techniques both in their mathematical treatment and in their application to real-world problems.

The book is divided into 12 chapters plus three appendices. The main portion of the book is represented by chapters 3–6, where the various approaches are identified, classified, and reviewed. Chapter 3 covers methods for generating nondominated solutions; chapter 4, continuous methods with prior preference articulation; chapter 5, discrete methods with prior preference articulation; and chapter 6, methods of progressive articulation of preferences. In these four chapters, close to 20 techniques are discussed with over 20 illustrative examples. This is both a strength and a weakness; the breadth of techniques and examples provide comprehensive coverage, but it is in a style too mathematically compact for most readers. By my count, the presentation of the 20 techniques in chapters 3–6 covered 85 pages, an average of about 4.5 pages each; therefore, a sound basis in linear algebra and linear programing is required if the reader hopes to follow the material. Chapter 2, "Concepts in Multiobjective Analysis," also assumes such a background.

Chapter 7, "Toward Multiobjective Stochastic Methods," gives an excellent overview of the influence of uncertainty in multiobjective optimization, an area sorely neglected and of importance to water resource planning. The main techniques discussed include a probabilistic tradeoff methods; formulation of a deterministic equivalent problem (a generalization of the standard chance constraint approach); the "u model" approach, where the cumulative of objective function random variables appears in the constraint set; a model formulation for probabilistic activity coefficients (in the constraints); and a discussion of stochastic, nondominated solutions. Examples are given in chapter 7; chapter 8 is an extended example on land reclamation after strip mining.

Two chapters were disappointing: chapter 10 on institutional settings of water resource planning and chapter 11 on a list of applications to real-world problems. It appears to me that chapter 10, while interesting today, restricts the book unnecessarily. It is of little use to readers outside the United States, and the material will quickly date the book. The mission, scope, or responsibilities of agencies change often and quickly; the Council on Environmental Quality has certainly changed (in spirit at least) since the manuscript was written. Chapter 11 does not (and probably cannot) give credit to the vast quantity of applications. To a large measure, the ones listed include those on which the authors have worked or with which they are familiar. These chapters add nothing to the book. They could easily be eliminated.

The one inconsistency in the book is in chapter 4 (section 4.5) where utility theory is presented. Utility theory interlocks with decision analysis where potential outcomes are uncertain. When outcomes from alternatives are uncertain, expected utility is an appropriate measure by which alternatives are evaluated. In the first six chapters, uncertainty was not addressed, and the correct preference structure for section 4.5 is multiattribute value functions, the deterministic equivalent to utility functions. The extension to utility functions and decision analysis for the purpose of evaluating alternatives with uncertain outcomes should appear in chapter 7 where stochastic methods are addressed.

Overall, the book is an excellent addition to the field. With the mix of theory, applications, and substantial number of problems following each chapter, the book can serve as an excellent textbook for the well-prepared and advanced student.

Eric Wood is with the Department of Civil Engineering, Princeton University, Princeton, NJ 08544.

Physico-Chemical Behaviour of Atmospheric Pollutants

B. Versino and H. Ott (Eds.), D. Reidel, Hingham, Mass., xvi + 672 pp., 1982, $1[illegible].

Reviewed by P. Crutzen

This book covers the proceedings of the Second European Symposium on the Physico-Chemical Behaviour of Atmospheric Pollutants, held September 29 to October 1, 1981, in Varese, Italy. These symposia are organized about every second year to coordinate research within the European Community and in Austria, Switzerland, Sweden, and Yugoslavia under a joint agreement called COST (Coopération Scientifique et Technique).

The book consists of 13 articles on the identification and analysis of pollutants, 11 on chemical and photochemical reactions, 12 on aerosols, 12 on pollutant cycles, and 21 on transport and modelling and field experiments and ends with five useful summaries written by the session chairmen.

It is impossible for the reviewer to start to discuss particular papers. As might be expected, the quality of the reported research is very unequal. As a rough guess, I predict that 25% of the material presented might be useful to American atmospheric chemists. However, the main value of the book, aside from being very readable, is that it is an overview of a significant portion of European pollution research.

P. Crutzen is with the Chemie der Atmosphäre, Max-Planck-Institut fuer Chemie, D-6500 Mainz, Federal Republic of Germany.

Classified

RATES PER LINE

Positions Wanted: first insertion $1.75, additional insertions $1.50.

Positions Available, Services, Supplies, Courses, and Announcements: first insertion $3.50, additional insertions $2.75.

Student Opportunities: first insertion free, additional insertions $1.50.

There are no discounts or commissions on classified ads. Any type style that is not publisher's choice is charged at general advertising rates. Eos is published weekly on Tuesday. Ads must be received in writing by Monday, 1 week prior to the date of publication.

Replies to ads with box numbers should be addressed to Box ___, American Geophysical Union, 2000 Florida Avenue, N.W., Washington, DC 20009.

For more information, call 800-424-2488 or 462-6903 (local).

POSITIONS AVAILABLE

Oceanographers. Assistant Professor, tenure track, position for applicants with recent Ph.D. and competence and interest in marine radioactivity and trace metal biogeochemistry. Duties will include development of research projects and some teaching. Salary negotiable depending upon experience and qualifications. Submit resume and names and addresses of three references by 1 September 1983 to: G. Ross Heath, Dean, School of Oceanography, Oregon State University, Corvallis, OR 97331. An AA/EEO Employer.

Research Professor in Marine Geoscience/University of Rhode Island. The Graduate School of Oceanography invites applications for a research professorship in Marine Geoscience whose salary and rank are negotiable. Preference will be given to candidates who have clearly demonstrated abilities and interest in, but not necessarily limited to paleomagnetism. The position is funded by contracts and grants, however the research professor holds full faculty rights in addition to other benefits. The paleomagnetic facility at GSO is fully equipped, fully operational and oriented towards rapid measurement of large numbers of soft sedimentary samples. Applications are now open for the position which will become available about January 1, 1984.

Send letters of application, resume, and names and addresses of three professional references to: Roger L. Larson, Graduate School of Oceanography, University of Rhode Island, Narragansett, Rhode Island 02882.

An affirmative action/equal opportunity employer m/f.

Hydrologist/Engineer. Participates in multidisciplinary research program to improve erosion prediction and erosion control. Primary emphasis on development of hydrologic concepts and mathematical relationships needed by fundamentally based erosion/sediment yield models for field sized areas. Career research position with U.S. Department of Agriculture at National Soil Erosion Laboratory on Purdue University campus in West Lafayette, Indiana. Minimum Salary: $24,508. For applications, contact Merle Bishop, USDA-ARS-NCRO-M, 2000 W. Pioneer Parkway, Peoria, IL 61615. Telephone 309-671-7184.

An Equal Opportunity Employer.

Research Scientist/Atmospheric Science/MIT. The Center for Meteorology and Physical Oceanography at MIT seeks applications from new or recent Ph.D.'s in atmospheric sciences for a research position involving the interpretation of NIMBUS-7 and SAGE satellite data on stratospheric trace gases and aerosols. The general aim is to improve our understanding of stratospheric chemistry and of the three-dimensional and residual-mean two-dimensional transport of tracers in the upper atmosphere. Appointment duration is one to three years. Familiarity with computing techniques used in multi-dimensional atmospheric circulation models is necessary. Please send curriculum vitae and names of three references to: Professor Ronald G. Prinn, c/o Vera Ballard, MIT, E19-258, Cambridge, MA 02139.

MIT is an equal opportunity/affirmative action employer.

Seismologist. The Institute for Petroleum Research and Geophysics in Holon, Israel, is seeking a seismologist to work on problems of earthquake risk assessment. Employment is for a period of one year with possible extension. Experience in statistical evaluation of earthquake risk is preferable but not mandatory. The Institute is a government owned company located in a suburb of Tel Aviv. It is responsible for most of the geophysical work in Israel and it has an active seismological program including countrywide and local telemetered seismic networks. Benefits include relocation expenses, housing allowance and a car. For details contact Dr. A. Shapira, Head, Seismological division, The Institute for Petroleum Research and Geophysics, P.O. Box 1717, Holon 58117, Israel; telephone 03-808112.

Iowa State University of Science and Technology, Department of Earth Sciences/Research Associate in Electron Microprobe. The Department of Earth Sciences invites applications for a Research Associate position as an electron microprobe specialist. The appointment will be a fully funded, permanent position. Salary will be commensurate with qualifications.

Primary duties are the operation and maintenance of a fully automated microprobe with WDS and EDS capabilities and the supervision of related laboratory facilities. Additional duties include instruction of research personnel in instrument operation. Ample opportunities exist for conducting collaborative and independent research involving the microanalysis of geological materials.

Applicants should have a M.S. degree in a science or engineering field, or equivalent experience, and experience with electron beam instrumentation. Persons with a working knowledge of WDS and EDS spectrometers and experience analyzing geological samples will be preferred applicants.

Application deadline is July 31, 1983. Later applications will be accepted if the position is not filled. Applications should furnish a complete resume, a statement of background and interests, copies of publications and names of three references. Applications should be sent to:

Bert E. Nordlie
Department of Earth Sciences
Iowa State University
253 Science I
Ames, Iowa 50011

Iowa State University is an equal opportunity/affirmative action employer.

University of Colorado, Boulder, Geochemist Position. Geochemist with active research program, stable isotopes, radioactive isotopes, and/or trace elements is being sought for a joint appointment in the Department of Geological Sciences and the Cooperative Institute for Research in Environmental Sciences (CIRES) of the University of Colorado.

The one-half time position within the Department of Geological Sciences is tenure track at the assistant or associate professor level with a starting salary of $12,000–$15,000 for the academic year.

Teaching load will be half that of full-time faculty. The position within CIRES will be as a Fellow with appropriate office and laboratory space. One-half academic year salary will be guaranteed by CIRES for two years at the departmental rate, after which incumbent must generate his/her CIRES salary from external sources. Incumbent may augment salary further by generating three months of summer salary from contracts and grants, and consulting.

Applicants with experience, publications, and/or movable existing research equipment preferred. Preferred starting date would be January 1, 1984. Closing date for applications is October 1, 1983.

Applications should include statement of research and teaching interests, experience, a full vitae, and four letters of reference.

Apply to: Professor Charles Stern, Chairman, Geochemist Search Committee, Department of Geological Sciences, Campus Box 250, University of Colorado, Boulder, CO 80309.

The University of Colorado is an equal opportunity/affirmative action, Section 504 employer.

Postdoctoral Positions in Earth Sciences. The Earth Sciences Division of Lawrence Berkeley Laboratory, University of California, anticipates openings for postdoctoral Research Scientists in geochemistry, reservoir engineering, hydrogeology, geophysics and geomechanics. Appointments are for a one-year term, and are normally renewable for a second year. Currently, some 30 staff scientists within the division are involved in a variety of fundamental and applied investigations that include field, laboratory, analytical, and numerical aspects. The selected candidates will be working in one of the following project areas: geological problems in nuclear waste disposal, geothermal reservoir engineering, flow in fractured and porous media, geophysical exploration technology, toxic element or radionuclide transport and reactions, borehole geophysics or similar projects. A close working relationship exists in many of the research programs with the faculty and graduate students of the adjacent University of California, Berkeley campus. A Ph.D. degree in a related field and 0–3 years' research experience beyond the Ph.D. thesis are essential. Please send two copies of your curriculum vitae and publication list to: Employment Office, Lawrence Berkeley Laboratory, One Cyclotron Road, Building 65, Berkeley, CA 94720. Please specify Job#A/2237 in all correspondence.

An equal opportunity employer, m/f/h.

LOS ALAMOS NATIONAL LABORATORY

ATMOSPHERIC / IONOSPHERIC PHYSICIST

The atmospheric sciences group of the Los Alamos National Laboratory is seeking a staff member to participate in research devoted to investigating the emission and propagation of signals from nuclear explosions in support of arms control treaties. The research activities include modeling, experimental design, and field experiments at remote sites. It is expected that research results will be communicated through published papers, reports, technical symposia, and program review panels.

Research competence at the PhD level in one or more areas of atmospheric or ionospheric science, as demonstrated by publication in refereed journals is required. Ability to solve problems in classical electrodynamics, magneto-hydrodynamics, or plasma physics is desirable. A PhD in physics, astrophysics, space physics, plasma physics or an equivalent combination of education and relevant experience is necessary. United States Citizenship is required.

The Laboratory, one of the nation's foremost scientific research organizations, is operated by the University of California for the Department of Energy. Our location in the mountains of northern New Mexico offers a pleasing life style; a pollution-free environment; and ample recreational activities. We offer competitive salaries and comprehensive employee benefits.

To apply, send resume in confidence to:

Madeline Lucas
Personnel Administration Division
DIV 83-AU
Los Alamos National Laboratory
Los Alamos, NM 87545

University of California
Los Alamos
Los Alamos National Laboratory
Los Alamos, New Mexico 87545

An Affirmative Action/Equal Opportunity Employer. Women, Minorities, Handicapped and Veterans are urged to apply.

Iowa State University of Science and Technology, Department of Earth Sciences. Applications are invited for a tenure track faculty position in Meteorology. Rank is at the assistant or associate professor level, dependent upon qualifications. The successful applicant will be expected to develop a strong research and graduate student program and will teach undergraduate and graduate courses for meteorology majors.

The position is for a person with proven expertise within the general area of dynamic meteorology. Teaching will involve an undergraduate course in synoptic meteorology, in addition to courses related to the field of expertise. Completion of the Ph.D. prior to appointment is strongly preferred. In addition, research ability shown by other publications and/or postdoctoral experience will be an advantage.

Iowa State offers degrees in meteorology through the Ph.D. The program includes about 60 undergraduate majors; the graduate/research program is strong and emphasizes theoretical, dynamic studies. Close relationships are established with the facilities and personnel of major national laboratories. New campus facilities for meteorology are currently under construction.

The appointment is expected to begin no later than September, 1984; an appointment during the current academic year may be possible. Application deadline is November 1, 1983; later applications will be accepted if the position is not filled. For application information please write to:

Dr. Bert E. Nordlie
Department of Earth Sciences
Iowa State University
253 Science I
Ames, Iowa 50011.

Iowa State University is an equal opportunity/affirmative action employer.

Atmospheric Science/SUNY-Albany. Tenure track position is available in Atmospheric Sciences Research Center. The staff member is required to conduct research on alternate energy sources, climatology, computer modeling and air quality. The successful candidate is expected to develop research proposals and engage in cooperative research with other staff and state-federal organizations. Ph.D. required and capability in two or three languages would be most helpful. Send resume to:

Dr. Raymond A. Castillo
ASRC—ES 324
State University of New York at Albany
1400 Washington Avenue
Albany, New York 12222

An Equal Opportunity Employer.

Research Scientist/Space Plasma Physics, University of Iowa. A research position is available in the Department of Physics and Astronomy, The University of Iowa, for theoretical and interpretative studies of waves in space plasmas. Specific emphasis is on theoretical investigations of wave-particle interactions in planetary magnetospheres and in the solar wind. These investigations are to support the interpretation of data being obtained from spacecraft projects such as Dynamics Explorer, International Sun Earth Explorer and Voyager. The applicant must have a Ph.D. with good qualifications in plasma physics theory and should have some experience in the interpretation of space plasma physics data.

Send a resume and the names of three references familiar with the applicant's work to: D.A. Gurnett, Department of Physics and Astronomy, The University of Iowa, Iowa City, Iowa 52242, telephone 319-353-3527.

The University of Iowa is an affirmative action/equal opportunity employer.

Geophysicist/University of Saskatchewan. Subject to final budgetary approval, the Department of Geological Sciences will have a new tenurable position in geophysics available July 1, 1984. Applicants should hold, or be about to receive, the Ph.D. or equivalent degree. They will be expected to teach undergraduate and graduate courses in geophysics and to build and maintain a vigorous research program. Excellent research opportunities exist in crustal and exploration seismology and in all fields of mining geophysics. The department, to occupy a new building in 1985, already has well-equipped geophysical and data-processing facilities. Applicants should send a letter outlining their teaching and research goals, accompanied by a full curriculum vitae including the names of at least three referees, to Dr. W. G. E. Caldwell, Head, Department of Geological Sciences, University of Saskatchewan, Saskatoon, Canada S7N 0W0.

Chairman—Department of Geological Sciences, Wright State University. The Department of Geological Sciences, invites applications for the position of chairman, to be appointed September 1984. We seek a dynamic individual with administrative talent and an appreciation for research and practice-related educational activities. Rank is at the full professor level and no restrictions have been placed on areas of specialization. The department is active with 12 faculty and an emphasis on professional practice, yet maintaining a firm commitment to basic research.

Send a letter of application, curriculum vitae and names of three references to:

Chairman, Search Committee
Department of Geological Sciences
Wright State University
Dayton, OH 45435.

Wright State University is an affirmative action/equal opportunity employer. Closing date for the position is October 31, 1983.

Research Scientist II. The Solar-Terrestrial Theory Group at the University of New Hampshire seeks applications for a research scientist II to undertake a variety of theoretical problems on plasma and MHD processes in the solar atmosphere and the solar wind, and related energetic particle phenomena.

Minimum qualifications: Applicant must possess a Ph.D. or equivalent professional degree, with research leading to doctorate, with training in theoretical space plasma physics or a related field, (e.g., theoretical plasma fusion research), or masters degree and at least three years of research experience which is closely related to project work. Salary range $20,110 to $31,280; normally starting salary not to exceed $22,510. Resume and three letters of reference should be sent before August 15, 1983, to: Dr. J. V. Hollweg, Department of Physics, University of New Hampshire, Durham, NH 03824.

The University is an affirmative action/equal opportunity employer.

Mass Spectrometry/Washington University. The Department of Earth and Planetary Sciences of Washington University in St. Louis has an opening for a mass spectrometry specialist in a recently established thermal emission mass spectrometry laboratory. This position will involve responsibilities for the operation and maintenance of the laboratory as well as opportunities for collaborative and independent research in isotope geochemistry. A Ph.D. in physical science and prior experience in thermal emission spectrometry are highly desirable. Closing date for applications is September 15. Send to F.A. Podosek, Department of Earth and Planetary Sciences, Washington University, St. Louis, MO 63130.

Washington University is an equal opportunity/affirmative action employer.

Florida International University/Faculty Positions in Geology. The Earth Sciences program at Florida International University is expanding and plans to increase the number of its faculty positions in the next few years. In order to complement existing instructional and research strengths, the university invites applications for tenure track positions at the assistant professor level in the following areas of specialization.

1. Stratigraphy/Sedimentology
2. Geophysics/Marine Geology
3. Igneous Petrology/Geochemistry/Economic Geology

Successful applicants must have demonstrated an ability to conduct high-quality teaching and the potential to establish a productive research program in their area of specialty.

Subject to final approval of funding, appointments will begin in August 1983 (deadline for application July 30, 1983) and/or January 1984 (deadline for application November 15, 1983).

Send a resume, brief description of teaching and research interests, transcripts and three letters of recommendation to:

Dr. L. Keller
Department of Physical Sciences
Florida International University
Tamiami Trail, Miami, Florida 33199

Florida International University is a member of the Florida State University system and an affirmative action/equal opportunity employer.

Visiting Research Scientist Radio Emission Processes

Applications are invited for a visiting research scientist position in the Department of Physics and Astronomy, The University of Iowa, Iowa City, Iowa.

This position is intended to support a multidisciplinary study of planetary, solar and astrophysical radio emission processes funded by the NASA innovative research program. Applicants must have a Ph.D. with a good theoretical background in basic plasma physics and experience in either experimental or theoretical studies of planetary, solar or astrophysical radio emissions. Our intention is to favor established scientists with research experience in this area, although junior scientists with an appropriate background will also be considered. The salary will be commensurate with the experience level. The appointment can be for any period up to one year, with a possibility for extension to a second year, depending on funding constraints.

Send curriculum vitae and a list of three references to:

D. A. Gurnett
Department of Physics and Astronomy
The University of Iowa
Iowa City, Iowa 52242
Telephone 319/353-3527.

The University of Iowa is an affirmative action/equal opportunity employer.

Applications are invited for a faculty position in

MICROPALEONTOLOGY

at the Department of Earth Sciences of ETH and University of Zurich.

The new professor will be responsible for teaching and research in micropaleontology. The successful candidate will have experience in precise stratigraphical work in marine and continental sediments and should be familiar with the application of quantitative methods. He is expected to teach at undergraduate and graduate levels and to cooperate with scientists within and outside the universities.

Applications with curriculum vitae and list of publications should be submitted before September 30, 1983, to the President of ETH Zurich,

Prof. H. Ursprung
ETH-Zentrum
CH-8092 Zurich

AGU

Membership Applications Received

Applications for membership have been received from the following individuals. The letter after the name denotes the proposed primary section affiliation; the letter A denotes the Atmospheric Sciences section, which was formerly the Meteorology section.

Regular Member

Gretchen E. Anderson (V), Michael Audley-Charles (T), Ognjen Bonacci (H), W. J. Bond (H), Yie Ming Chen (O), Hong-Yee Chiu (SS), Sung Kwun Chough (O), Hendrik J. Colenbrander (H), Kevin D. Crowley (T), Carol A. Dickerson (H), Bruce Douglas (T), E. M. Durrance (H), Daniel Hubert, Jack C. Hwang (H), Pratt H. Johnson (P), Robert G. Knollenberg (A), Paul M. Kohic (A), David J. Lamb (S), Sydney Levitus (O), Jean C. Lewis, Roger Lukas (O), James F. Lynch (S), Jayne E. May (H), Matti J. Melanen (H), Anthony R. Mondie (H), Hiroshi Mori (T), M. A. Naylor (T), Mitiyasu Ohnaka (S), Guizhong Qi (GP), Ashok Kumar Rastogi (H), Hiroki Sato (T), J. D. Stoner (H), David A. Stonestrom (H), Kenneth H. Turner (T), Frans H. M. Van De Ven (H), Margaret D. Wilson (SM).

Student Member

David T. Allison, Winnifred Au (O), Phyllis Zycki Bunlka (P), William Corso (T), Jonathan M. Cutler (T), Donald B. Dlugveil (V), Brian M. Hodil (S), James J. Dow (H), Gregory Lee Enger (S), Jurgen Farbrecht (H), Larry J. Granroth (SM), Scot M. Graves (V), Ronald C. Grosh (A), Jung Han (S), Ann P. Harca (T), Charles E. Heywood (T), Robert V. Hilmer (SM), Kathleen Hogue (H), Eric S. Johnson (O), Peter J. Kelly (O), Irwin S. Krinsky (SS), Marlon R. Lewis (O), Mark Mandt (SM), Philip Murrisey (H), Mike Newchurch (A), Vicente Nogueira (H), R.M.D. Rathnayake (H), Walter A. Robinson (A), Audrey Shipley (H), John R. Smith (V), Kenneth R. Snow (S), Stephen R. Solton (P), Carlos E. Tamayo-Lara (H), Ching-Pi Wang (T), Peter M. Wohlgemuth (H), Lancy Yau (V), Nancy K. Zeller (O), F. Ramon Zaniga (S).

Associate Member

John G. Catts (V), William C. James (H), Don Mottis (T), Rein Tirrul (T).

Public Affairs Committee Actions

The AGU Public Affairs Committee will create an ad hoc committee to consider possible AGU position statements concerning the effects of nuclear war.

The action was taken at the May 31, 1983, meeting of the Committee at the AGU Spring Meeting in Baltimore. Present were Carroll Ann Hodges, Chairman, and members Thomas J. Ahrens, David Cauffman, Jared Cohon, Stamatios Krimigis, Robert Murphy, Raymond Roble, and George Shaw. Also attending were the current Congressional Fellow Jim Weissman and SPR–Cosmic Rays Section Secretary Miriam Forman.

Most of the Committee's all-afternoon meeting focused on the issue of nuclear arms limitation. The question, brought up by Miriam Forman, was whether the Committee should ask the AGU Council to name a panel of experts to draft an AGU position statement, after the fashion of the recent American Physical Society resolution. The Committee agreed that, operating under the Union's policy on advocacy (see box), AGU has a valid scientific basis for commenting on the effects of nuclear war but that options other than a published general resolution should be considered. Before recommending action to Council, the Committee decided to designate an ad hoc committee to consider all possible options for an effective AGU contribution to this ongoing debate.

The committee also considered topics for public-issues symposia at future national AGU meetings. It concluded that the time seemed right for consideration of a scientific session on the geophysical and geochemical effects of nuclear war. Thomas Ahrens and Joseph Smith were designated as coconvenors and asked to make a proposal to the Fall Meeting Chairman.

The Committee also covered the following issues:

• The Committee voted to recommend to Council that the Congressional Fellows Program be continued for 1984–1985. This proposal was subsequently approved by Council at its meeting. The number of applicants for 1983–84 was up substantially from previous years and the calibre of candidates was high. The new 1983–1984 Congressional Fellow is Jack Fellows, a hydrologist from the University of Maryland. He has just completed his Ph.D. in Civil Engineering.

• The *Eos* news writer has established valuable contacts on Capitol Hill and in the relevant federal agencies and is getting increasingly well acquainted with the information network. The committee is closely watching the expanding government coverage.

• An updated AGU Guide to Legislative Information was reviewed favorably and minor revisions were suggested by the committee. A summary of this document will appear soon in *Eos*; it was suggested that the complete document be published in *Eos*, perhaps with the biannual membership directory. All committee members will have copies and any member wishing to receive a copy may obtain one by writing to AGU headquarters.

• The Science/Policy College Seminar series that was approved by Council is well along in planning. About a dozen AGU members, including former fellows, have been identified as participants. The committee will be looking for additional participants through advertising in *Eos*.

• The AGU Contact List of Geoscientists, which is a list of AGU members who have agreed to talk to the press on specific topics and have been approved by the section officers, is on file at headquarters. Anyone interested in being on this list or getting information from it should write to AGU headquarters.

• AGU public affairs activities had been supported for several years by RDD Associates of Denver. RDD's functions have now been taken over by the Subcommittee. As part of this change, the Subcommittee's Public Information, which was made up of AGU members in the Denver area, will be placed by a local Washington, D.C. committee.

Comments on the public affairs programs and questions of concern are welcome and should be addressed to chairman Hodges at the AGU headquarters address.

Advocacy and AGU

In May 1982 the AGU Council approved the following policy on the Union's role in advocacy on public issues:

The American Geophysical Union is an association of scientists, scholars, and interested lay public, for the purpose of advancing geophysical science. The Union shares a collateral sense of responsibility to assure that the results of geophysical research are made available to benefit all mankind. The Union encourages its members to exercise their individual sense of responsibility in addressing political and social issues. Should they choose to act collectively on such issues, other organizational fora exist for such purposes. The American Geophysical Union, as a society, should preserve its unique position as an objective source of analysis and commentary for the full spectrum of geophysical science. Accordingly, the following policies should guide the American Geophysical Union's role as an advocate:

• The American Geophysical Union has a responsibility to its members to adopt a position of advocacy on geophysical science issues based on their intrinsic merits and needs.

• To the extent that the understanding and application of geophysical science is relevant to public policy, AGU, as a responsible scientific association, should make relevant information available to all parties interested in the issue.

• As a scientific society AGU should not take or advocate public positions on judgemental issues that extend beyond the range of available geophysical data or recognized norms of legitimate scientific debate. Public positions adopted by AGU and statements issued on its behalf must be based on sound scientific issues and should reflect the interests of the Union as a whole.

1983 James B. Macelwane Awards

William L. Chameides

Citation

It is with great pleasure that I put forward, as one of the winners of the 1983 Macelwane awards, Dr. William Chameides. Dr. Chameides, Associate Professor of Geophysical Sciences at the Georgia Institute of Technology, has made several significant contributions to the area of atmospheric chemistry: his doctoral dissertation on the photochemistry of tropospheric ozone remains today, 10 years later, an area of intense scientific investigation; his work on the chemistry of lightning has altered our understanding of the atmospheric Nitrogen cycle, and his most recent groundbreaking research on the impact of photochemistry upon the aqueous phase has already revolutionized our understanding of the chemistry of clouds.

Dr. Chameides began his professional career in atmospheric sciences under the direction of Professor James C. G. Walker, then at Yale. Not unlike many highly regarded individuals in this aggressive age of science, Bill's very first publication was a major one dealing with 'A Photochemical Theory of Tropospheric Ozone.' Previous to the Chameides and Walker work, the thinking generally held by the atmospheric sciences community was that ozone in the troposphere was predominately produced in the stratosphere and only later mixed down into the troposphere. Once in the troposphere, it was considered chemically inert and thus was thought to be removed from the lower atmosphere by deposition at the earth's surface. Chameides and Walker were the first to propose a quantitative model which predicted that photochemical production and destruction could have a controlling influence on the tropospheric ozone budget. The hypothesis put forward generated intense debate among scientists in the field, a debate which continues even today. And though positions are still changing, most active players involved in this debate agree that the contribution of photochemistry to the tropospheric ozone budget can no longer be ignored.

Bill's efforts in atmospheric science, however, have involved far more than his major contribution to our understanding of tropospheric ozone. Papers published in 1977, 1979, and again in 1981 related to a totally different topic: the influence of lightning on the chemical composition of the atmosphere. The idea that lightning might produce significant quantities of atmospheric trace gases is not a new one. In fact, as early as 1870 von Liebig proposed that lightning was a significant source of atmospheric NO_x.

Von Liebig's estimates, however, were based on very qualitative information. In 1977, Chameides and coworkers developed the first model that permitted a quantitative assessment of the amount of NO plus other gases that could be produced in a single lightning stroke. This model has now been confirmed in simulated lightning experiments in the laboratory. Much work still remains in extrapolating these single stroke modeling results to the global atmosphere, but the effort by Chameides and coworkers in this field is already regarded as a major development. As further evidence of this, Chameides has extended many of the basic findings from this model to other unique atmospheric problems. Two of the more noteworthy ones are: the chemical impact of lightning on the atmospheres of Venus and Mars; and, the lightning fixation rate of carbon and nitrogen in the prebiological earth atmosphere.

Bill has also had successful research ventures into stratospheric/tropospheric modeling studies involving halogens and hydrocarbon species and into such diverse topics as studies on the atmospheric budgets and chemistries of sulfur and iodine. Clearly, one of his most significant recent accomplishments has involved a study encompassing both the fields of physical meteorology and atmospheric chemistry, in what is now labeled "cloud chemistry." Historically, attempts to model this complex system have been relegated to treating the chemistries in the gas and aqueous phases independently, or at best, as weakly interacting. Chameides and his coworker Dr. Douglas D. Davis have now proposed a new mechanism, one which appears to represent a critical new pathway in the evolution of cloud chemistry.

This new hypothesis reflects the idea that one of the major chemical driving forces within clouds could be the gas phase photochemical production, and subsequent hydrometeor scavenging, of the free radical species OH and HO_2. This new, free-radical chemistry not only allows for the oxidation mechanisms operating within hydrometeors to be driven faster, but it also permits the generation of numerous new species within the aqueous phase, some of which can be returned to the gas phase through cloud cycling processes. Without a doubt, the Chameides and Davis gas phase/heterogeneous/aqueous phase cloud model has precipitated a major rethinking of cloud chemistry.

I believe that Bill's very major contribution to this latest effort on cloud chemistry modeling testifies well for the creative intellect possessed by this still blossoming young scientist. His native ability in selecting productive new research problems is a continual source of amazement and excitement for those individuals that interact with him. Equally important, though, has been his steady stream of innovative ideas for systematically attacking these new research problems. Bill's published work has had its greatest impact in global atmospheric chemistry. However, his contributions to the related fields of air pollution chemistry, marine chemistry, and planetary atmospheric chemistry have also received high acclaim from researchers within these fields. I have every reason to believe that, given Bill's creative disposition, he will continue to perform in a research leadership role in many of those fields for many years to come.

C. S. Kiang

Acceptance

I am not sure which was the greater shock for me when I first heard of the plans for tonight's awards ceremony: the fact that I would be one of the Macelwane Award recipients, or that I would be expected to wear a tuxedo. But, as you can see, here I am, in my tux, so I guess small miracles really do happen.

Throughout my career in the earth sciences I have had the good fortune to be associated with highly talented individuals. These include Jim Walker, my thesis advisor; Andy Nagy, Ralph Cicerone, Shaw Liu, and Don Stedman, who I worked with while a post-doc at the University of Michigan; Alex Green, my associate at the University of Florida; and, of course, my very good friends and colleagues C. S. Kiang and Doug Davis, who have created the kind of stimulating and challenging environment at Georgia Tech where any scientist would flourish. Without their help and collaboration it would never have been possible for me to be before you tonight, and, so, in accepting this award I must also accept it in the names of these other individuals as well.

However, there is an even larger group of people with whom I must share this award: the community of scientists studying atmospheric chemistry. While I have often heard the refrain, "Atmospheric chemistry is a science in its infancy," the field is really not a new one. Famous chemists from the 18th and 19th centuries such as Priestley, Lavoisier, Cavendish, and Arrhenius all studied the atmosphere. Yet, because the atmosphere was not their primary research interest, atmospheric chemistry was never recognized as a scientific discipline in its own right. It has only been in the last 10–20 years that a community of scientists has banded together and dedicated itself to understanding the chemistry of the atmosphere. The results have been remarkable. We have learned of biogeochemical cycles and of the central role free radical species play in these cycles. We have also learned that these cycles can be perturbed by the chemicals our technological society releases into the environment. There is no doubt in my mind that my receiving this award tonight is in large measure a result of the great progress this community has made in the past decade. That I have been able in my own small way to have taken part in this scientific adventure is a great source of pride and satisfaction for me, and the award tonight makes it all the more meaningful.

William L. Chameides

Donald J. DePaolo

Citation

We honor Don DePaolo with the Macelwane Award for several key contributions to the earth sciences. While a graduate student at Caltech Don recognized that the study of an isotopic parent–daughter pair having the same volatility and the same host phases could eliminate many of the ambiguities that had plagued previous attempts to apply isotopic data to the study of mantle reservoirs and that the ^{147}Sm–^{143}Nd system was such a geochemically coherent pair.

Following Gunter Lugmair's pioneering work on meteorites, Don was one of the first to work out laboratory techniques for the study of Sm and Nd; these techniques and the high-precision mass spectrometers of the Wasserburg lab allowed Don and Jerry to demonstrate in several key papers that there were at least two major mantle reservoirs and to examine earth structural models that could account for the observations. Don continues to contribute new ideas to this area; for example, in a paper in press he discusses the use of ^{176}Lu–^{176}Hf results to place constraints on the rate of crustal recycling.

In addition to his laboratory and model-building skills Don is an excellent petrologist and field geologist. He won the Caltech prize for field geology as a graduate student, and he teaches field geology and petrology at UCLA. He recently played a major role in revising our undergraduate petrology curriculum.

Don came to UCLA in 1978, and within two years had established a laboratory that could yield precision isotopic ratios and low elemental blank levels that were equal to the best being achieved elsewhere in the world. He attracted a large number of our best graduate students, and the mass spectrometer began operating around the clock. Lang Farmer just became the first person to get a Ph.D. with Don. The Farmer-DePaolo study of the granites of the Western U.S. is a tour de force using chemical, isotopic, geological, and geophysical evidence to evaluate a major regional problem. This study especially reflects the fact that Don's broad viewpoint carries over into all his research.

Don is already recognized for innovative leadership in the earth sciences. One of the most stimulating discussion sections at the 1981 Airlie House symposium on early crustal genesis was that led by Don and Frank Richter.

I speak for many of Don's friends and colleagues when I say that we are most grateful that he was chosen for the Macelwane Award, and we look forward with pleasure to the many important insights he will produce during the coming decades.

John T. Wasson

Acceptance

It is a great pleasure for me to receive the J. B. Macelwane Award. I would like to express sincere gratitude to my colleagues at UCLA, who nominated me, to the award committee, and to all of the members of the AGU for this honor.

For an experimentalist, and perhaps in particular for an isotope geochemist, it goes without saying that all research accomplishments represent the efforts of many people, either directly or indirectly. To cover my debts adequately would take more of your time than I am free to command, but I wish to name a few at least, while apologizing for the many left unmentioned. Perhaps my greatest debt is to Caltech for an experience as a graduate student that awakened in me the desire to try to understand geologic processes in a quantitative way, and at the same time provided me with the opportunity to acquire the tools that are needed.

At Caltech my love of earth science was reconciled with my fetishes about well-defined problems and quantitative approaches. My interactions with Hugh Taylor, and, of course, with Jerry Wasserburg were particularly significant. Jerry's ability to separate the scientific wheat from the chaff, has been a strong influence in shaping my research. In a more specific vein, I owe my interest in granitic rocks to stimulating courses and field mapping trips to Baja California with Lee Silver, where, among other things, I learned to appreciate the "rabbit in the moon," Dos Equis, agave, sweet bread, and poverty.

Upon leaving Caltech for UCLA my main problem was one that involved a few hundred kilodollars. I am extremely grateful to Clarence Hall, Harold Ticho, and others at UCLA, who managed to wrangle for me an unprecedented amount of support to allow construction of a mass spectrometry laboratory, and to my colleagues at the National Science Foundation, who were willing to place a large bet on a unproven horse.

My work at UCLA has been facilitated by exceptionally capable support on all fronts, and a stimulating group of graduate students. The biggest single factor in the success of the laboratory operation is my exceptionally careful, cooperative, and capable technician, Tom Owens, who has handled so many aspects of the lab operation so well that I would be embarrassed to mention them all.

Finally, I would like to use this opportunity to publicly thank those who have unselfishly helped me and my students by providing samples for isotopic studies, as well as their time and knowledge, especially Ron Kistler, Carl Hedge, and Fred Barker of the USGS, Sm McCallum, and Linda Raedeke of the University of Washington, and Tony Morse of the University of Massachusetts.

The research I do can be described as the application of heavy isotope ratio variations, produced by the decay of naturally occurring radioactive nuclides, to geological problems of various types. This field has experienced substantial growth in recent years, largely as a result of the efforts of people like Jerry Wasserburg, Claude Allegre, Mitsunobu Tatsumoto, Günther Lugmair, and others. My work has followed in a natural way from theirs, and my presence here is a tribute to them.

In closing, I would again like to thank all those who have helped me along and enriched my life in the process. To paraphrase the kind, but prodding, words of my mentor: I am pleased to be *Mac*'ed and promise I will not *wane*.

Donald J. DePaolo

Thomas H. Jordan

Citation

Tom Jordan has made a fundamental contribution to our understanding of the grandest-scale problems of the earth's tectonics by stimulating our consciousness about the deeper part of continents. He has stimulated not only seismologists and other geophysicists but also geochemists by introducing the idea of the continental tectosphere.

This idea, of which the origin can be traced to his Ph.D. thesis, has given a unity to his impressive body of work accomplished over the past decade employing a variety of approaches ranging from mathematical to geochemical. It is rare that a scientist at such an early stage of his career conceives an original working hypothesis which then keeps him productive, diversified, and developing consistently over a decade.

His Ph.D. thesis work, supervised by Don Anderson at the California Institute of Technology, made at least three important contributions to geophysics. First, he constructed an earth model called "B1," which was used as a reference model for various purposes. Second, he was the first to apply the now widely used stochastic inverse method to a geophysical problem. And third, he established the so-called baseline problem—that is, the discrepancy between free-oscillation data and travel-time data—which led him to postulate a difference in deep structure between continents and oceans.

AGU (cont. on p. 490)

AGU (cont. from p. 489)

Among the numerous important contributions that followed his thesis work and covered a broad area of geophysics and geochemistry, two seismology papers impressed me most. One described the discovery (made jointly with his student, Stuart Sipkin) of a systematic variation in differential ScS times for various tectonic regions, from old continents to young oceans. Tom attributed this variation to the difference in deep structure between shield and ocean, although his interpretation was later questioned by other seismologists, including his mentor Don Anderson. The other work is a theoretical paper on the free oscillation periods for a laterally heterogeneous earth. He showed that the center period of a peak of multiplet split by lateral heterogeneity can be simply related to the mean phase velocity of the great circle path passing through the source and receiver. He further proposed a practical procedure for estimating lateral variations from observed free-oscillation data, and made a first such attempt jointly with another student, Paul Silver.

Sometimes the stereotyped seismologist with his preoccupations about mathematical difficulties of wave propagation in an overly simplified earth model is characterized as narrow and ignorant. Tom Jordan is the best example of a new breed of seismologists who are broad, knowledgeable, in command of mathematics, physics, and chemistry, and who contribute greatly to our understanding of the structure and dynamic processes of the earth's interior. It is my great pleasure to offer this citation of Tom Jordan upon his receipt of the prestigious Macelwane Award.

Keiiti Aki

Acceptance

Those of us fortunate enough to receive this award have been lucky enough to have the guidance and inspiration of great teachers, both within the academies and without. I thank the AGU for this opportunity to express my gratitude to those who helped me in establishing my scientific career, because it is to their efforts that this honor is dedicated.

In October, 1967 I turned 19 years old. The plate tectonic revolution was breaking across the earth sciences like a huge wave, but as an undergraduate at Caltech I was ignorant of geophysics and unenthusiastic about science in general. Although I had a parttime job running seismometers around southern California, the west coast was rocking from more than earthquake waves, and the epicenter was San Francisco. My grades were poor and my recklessness high, so I had made up my mind to drop out of science and transfer to Berkeley. Fortunately, my father stopped by Pasadena on his way to Vietnam, and he and Jerry Wasserburg argued me out of it and saved me from being swept into the vortex which in the late sixties consumed so many of my contemporaries.

Just a few weeks later Don Anderson phoned me up and invited me to be undergraduate assistant, thus initiating five years of collaborative research which culminated in my thesis work on radial earth structure. It was Don who, with his creative spark, ignited my enthusiasm for the field of geophysics and showed me its landscape. He taught me the penetrating power of a novel working hypothesis, the fertility of a mind nurtured by observations from many disciplines, and the need for synthesis in the geosciences.

Synthesizing large data sets into models was a growth industry by 1969, so in the spring Don drove me down to La Jolla to meet the captains of that industry, George Backus and Freeman Gilbert. In observing the habits of Scripps professors, it did not take long to realize I had discovered California's version of Eden; not only could you live the life of a beach bum and get paid for it, but you could do so on a really high-class beach. I had read the Backus-Gilbert papers, of course, but it still took Freeman Gilbert hours to straighten out my fuzzy thinking on the subject.

Freeman helped me along at various times during my graduate career, impressing on me the need for precise thinking, careful analysis, and well-constructed null hypotheses. He also agreed to serve on my dissertation committee, and his participation proved crucial. On the morning of my doctoral defense, I got an unexpected call from the Registrar's office informing me that, although I had completed the requirements, I had failed to apply formally for Candidacy Status and was thus ineligible to take my exam. It was the midsummer of 1972, and it took several hours to locate a dean with sufficient authority to sign the appropriate documents. I cornered him at home beside his pool, but he refused to approve of the matter on such short notice until he was informed that the distinguished Professor Gilbert had traveled all the way from La Jolla to attend the exam. My defense was only slightly delayed, I passed, and Robin and I loaded up our old Ford for the trip to Princeton, where my first teaching job awaited.

Teaching has been my preoccupation for 11 years now, and it is to my students in this audience that I would like to give a special word of thanks. In my attempts to teach you the practice of science, I have learned most of what I know about it as well as a lot about myself. My published research during this last decade has been largely the work we did together, and you deserve to share in the satisfaction of this award.

Special appreciation is also due my colleague Bernard Minster. We have been actively collaborating since our first year of graduate studies, and we have had one hell of a good time. Bernard was a little homesick his first year in the States, so he consoled himself by buying, on our rather meager graduate-student stipends, good French wines, which we drank late into the night while formulating harebrained schemes to do earthquake statistics, design heat-flow probes, or model plate motions.

About this time Bernard introduced me to Robin, who is now my beautiful wife but then lived above us in a rickety old apartment building in Pasadena. Robin quickly learned the hazards of consorting with seismologists. When the three of us decided to combine our fortunes and move to a more substantial residence, we vacated our apartments with only one day's notice, announcing to our landlord and fellow tenants that we were moving out because, as seismologists, we considered the place to be structurally unsound and incapable of withstanding the inevitable earthquake.

As it happens, that was the beginning of February 1971, just one week prior to the San Fernando earthquake. When it occurred, Bernard and I were gone from our new house in a flash, not returning from the field for several days and leaving Robin to explain to the angry callers that, no, Bernard and I did not have the knowledge to predict this disaster and, no, we had not withheld this information from our former friends in the damaged apartment building. Since that time Robin has participated with me in the joys, frustrations, and grind of doing science; if there were justice, her name as well as mine would be inscribed on this award.

Finally, let me express my gratitude to all my other colleagues whose names cannot be mentioned here but whose help I have freely taken as it has been freely offered. This award, tied as it is to a specific calendar age, cannot help provoke in me a certain nostalgia. It has struck me during the last few months that I can detect so few signs of aging in the faces of my contemporaries; we do not appear to be getting any older. But I should also note that, as I look out into this audience, I can see that those around us are definitly getting younger.

Thomas H. Jordan

Meetings

Announcements

Infrared Backgrounds

The 1983 Tri-Services Infrared Backgrounds Symposium will be held on October 18–20, 1983, at the MITRE Corp., in Burlington, Mass. Sponsored by the Department of Defense, the symposium will deal with such topics as recent data, models, and analysis of all aspects of infrared backgrounds (terrain, atmospheric, and space). Of special interest are new contributions on the following topics: downlooking backgrounds for missile surveillance, downlooking backgrounds for air vehicle surveillance, uplooking deep space surveillance, and disturbed atmospheres.

Those interested in submitting papers are asked to send a one page abstract to R. E. Murphy, AFGL/OPR, Hanscom AFB, MA 01731 by September 2. Because portions of the proceedings are classified, participants must submit their clearance (including Department of Defense sponsor) to the AFGL Security Office/SUL, Hanscom AFB, MA 01731, Attn.: P. Doyle.

Hydrogeology Symposium

The Geological Society of America's (GSA) Hydrogeology Division will hold a half-day session on hydrogeology during the 1984 meeting of the GSA Northeast Section at Brown University in Providence, R. I., March 14–17, 1984. The symposium will focus on the theory and application of advanced scientific methods and statistical approaches to hydrology and groundwater geology.

Abstracts (200 words or less) of proposed presentations should be submitted no later than September 1, 1983, to Frank J. Wobber, Office of Energy Research (ER-75), U.S. Department of Energy, Washington, DC 20545. GSA members and others with professional interests in hydrology, groundwater geology, and allied disciplines are invited to submit abstracts. Papers not accepted for the 1984 meeting will be reconsidered for 1985. If sufficient interest is expressed, seminars or workshops also may be scheduled.

The symposium is being organized by Wobber and Jeff Sgambat, Geraghty and Miller, Inc., 844 West Street, Annapolis, MD 21401 (telephone: 301-268-7730).

Erosion Control

The 15th Meeting of the International Erosion Control Association will be held in Denver, Colo., February 23–24, 1984. The conference's theme, "Erosion Control. . .Man and Nature," aims to emphasize the worldwide problem of erosion control caused by nature as well as by man.

Papers are being sought on erosion control techniques, materials, equipment, and policy. Abstracts should be no longer than one double-spaced typed page and should be sent by October 15 to Grit Bovenkamp, Conwed Corporation, 8888 Appian Way, Hollywood, CA 90046 (telephone: 213-650-6429).

For additional information, contact the International Erosion Control Association, Inc., P.O. Box 807, Freedom, CA 95019 (telephone: 408-688-3228).

Shuttle Environment

The American Institute of Aeronautics and Astronautics' (AIAA) Shuttle Environment and Operations Meeting will be held in Washington, D. C., October 3–November 2, 1983. Topics to be covered at the conference include environmental effects, payload support, and data processing and control.

Additional information is available from AIAA, Meetings Department, 1633 Broadway, New York, NY 10019 (telephone: 212-408-9740). Billy M. McCormac at the Lockheed Missile & Space Company in Palo Alto, Calif., is organizing the conference.

Radio Science Conference

The U.S. Committee for the International Union of Radio Science (URSI) will sponsor its national meeting at the University of Colorado in Boulder January 11–14, 1984. The meeting will feature a large number of papers presented to the various URSI Commissions as well as a contest for the best papers submitted by graduate students. The students will be eligible for awards totaling $1750.

Authors interested in submitting papers for the various sections of the conference must submit their abstracts by October 1, 1983, to S. W. Maley, Chairman, Steering Committee, National Radio Science Meeting, Department of Electrical Engineering, University of Colorado, Boulder, CO 80309. Notifications of acceptence or rejection will be mailed to authors by mid-November.

Graduate students interested in participating in the competition for student papers should submit their papers by October 1, 1983, to Program Committee Chairman T. E. VanZandt, NOAA/ERL, R/E/AL3, 325 Broadway, Boulder, CO 80303. Three finalists will be notified by December 1, 1983; the finalists will be provided with travel and subsistence support for attending the meeting. Questions regarding the competition should be addressed to Sidney A. Bowhill, Department of Electrical Engineering, University of Illinois, Urbana, IL 61801 (telephone: 217-333-4150).

Even though papers on any topic of interest to one of the nine URSI commissions are welcome, some commission chairmen are soliciting papers for several topics. Contact the appropriate chairmen for more information: **Commission A**, Electromagnetic Meteorology (H. Hellwig; telephone: 617-927-8220): time domain measurements, filament and connector interfaces in fiber optics, electromagnetic field and antenna measurements, and accuracy and standard test models for network analyzers; **Commission B**, Field and Waves (C. M. Butler; telephone: 601-232-7231): numerical solution techniques for general scatterers, and random media and rough surface scattering; **Commission E**, Electromagnetic Noise and Interference (A. A. Giordano; telephone: 617-449-2000): measurement, modeling, and communication in the radio channel; **Commission F**, Remote Sensing and Wave Propagation in the Neutral Atmosphere, Oceans, Land, and Ice (E. E. Gossard; telephone: 303-497-6645): coherent scatter; **Commission G**, Ionospheric Radio and Propagation (K. Davies; telephone: 303-497-3551): high latitude ionosphere, modern ionospheric sounding techniques, ionospheric modification and heating, and incoherent scatter; **Commission H**, Waves in Plasmas (R. F. Benson; telephone: 301-344-7511): F region wave structures, active experiments in space, coherent wave–particle interaction in the magnetosphere, and antennas in plasmas; **Commission J**, Radio Astronomy (M. A. Gordon; telephone: 602-882-8250): solar radio astronomy, self-calibrating techniques for radio astronomy, and radio astronomy plans for space vehicles.

The 10 member-organizations of the Institute of Electrical and Electronics Engineers are cosponsoring the meeting.

Ocean Sciences Meeting
Abstract Deadline:
October 19, 1983
New Orleans, Louisiana
Jan. 23–27, 1984

AGU Chapman Conference on Magnetic Reconnection

October 3—7, 1983
Los Alamos National Laboratory
Los Alamos, New Mexico

Convenor: E. W. Hones, Jr.

Plan to attend this exciting program!

Topics of discussion to include:

- Theory of Reconnection
- Computer Models of Reconnection
- Reconnection at Earth's Magnetopause
- Reconnection in Laboratory Plasmas
- Reconnection in Astronomical Objects

For more information on registration and accommodations contact the AGU Meetings Department

2000 Florida Avenue, N.W.
Washington, D.C. 20009
800-424-2488 (toll free)
462-6903 (D.C. area)

Ocean Sciences Meeting: Registration & Housing

The 1984 Ocean Sciences Meeting of the American Geophysical Union (AGU) will be held January 23–27, 1984, in New Orleans at the Fairmont Hotel. Cosponsoring societies are the American Society of Limnology and Oceanography (ASLO); the Acoustical Society of America (ASA); the American Meteorological Society (AMS); the Marine Technology Society (MTS); and the Institute of Electrical and Electronics Engineers Oceanic Engineering Society (OES).

Some of the most compelling problems in modern science and technology span two or more traditional disciplines, and this is especially true of oceanography, which is an amalgamation of several sciences with technology. The 1984 Ocean Sciences Meeting is the second meeting to be established by AGU as a forum for interdisciplinary oceanic problems; it is an outgrowth of the success of the first, which was jointly sponsored by ASLO and AGU and held in San Antonio in 1982.

In addition to the ocean physics and biology topics covered in San Antonio, the 1984 New Orleans meeting will include atmospheric sciences, chemical and geological oceanography, underwater acoustics, and ocean technology.

Most of the special sessions being planned have a strong (but not exclusive) component of physical oceanography; the Warm Core Rings experiment and investigations of the El Niño phenomenon and biogeochemical cycles all illustrate the extension of physics into several other disciplines, and sessions are offered in each. A more extensive but still incomplete list of sessions and some of their chairmen is found below. Other subject areas may be added between now and the time of the meeting with the hope that the several hundred participants expected will find much to suit their interests.

Several simultaneous sessions will be held, including poster sessions, with ample provision for refreshments in the morning and evening. An active social program is planned so marine scientists from the various disciplines can meet and talk.

The 1984 Ocean Sciences Meeting is an opportunity to advance the unity of ocean science and engineering in a stimulating and pleasant environment. We hope to see you there!

Registration

Everyone who attends the meeting must register. Preregistration (received by January 6, 1984) saves you time and money; the fee will be refunded to you if AGU receives written notice of cancelation by January 16. Registration for 1 day only is available at one half of the applicable preregistration rates, either in advance or at the meeting. Registration rates are as follows:

	Preregistration	After 1/6/84
Member	$65	$80
Student member	$32	$47
Retired senior member	$32	$47
Nonmember	$85	$100
Student nonmember	$30	$54

The difference between member (or student member) registration and nonmember registration may be applied to AGU membership dues if a completed membership application is received at AGU by April 25, 1983. Current AGU dues are $20 members; $7 student members.

To preregister, fill out the registration form, and return it with your payment to the AGU Office. Your receipt will be included with your preregistration material at the meeting. Preregistrants should pick up their registration material at the preregistration desk at the Fairmont Hotel. Complimentary badges for guests not attending scientific sessions will be available at the registration desk.

Hotel Accommodations

The meeting will be at the elegant Fairmont Hotel, which is at the edge of the Vieux Carré (French Quarter). In the experience of the Program Committee it is one of the finest facilities anywhere for supporting a technical meeting.

A block of rooms is being held at the Fairmont Hotel. Room rates are $60 single, $60 double. All reservations must be guaranteed by a first night's deposit or American Express, Carte Blanche, or Diner's Club card number. Read the housing application form and mail the completed application directly to the Fairmont Hotel, Reservations, University Place, New Orleans, LA 70140. MAIL EARLY to ensure confirmation. Deadline for reservations is December 23. Please do not write or call AGU for room reservations.

Social Events

An Ice Breaker on Monday evening from 5:30–7 P.M. at the Fairmont is the opening social event of the meeting.

On both Tuesday and Thursday evenings a social hour from 6:30–8 P.M. has been tentatively scheduled so participants may gather to make plans for evening activities.

There will be a Wednesday luncheon in the Imperial Ballroom from noon to 2 P.M. The luncheon speaker will be announced in a later issue of *Eos*. Tickets are $12. Purchase your ticket early; there will be only a limited supply at the meeting.

Scientific Sessions

The Call for Papers showing specifications for abstracts was published in the July 5 *Eos*. The program summary will be published in the November 29 *Eos*. The preliminary program along with the abstracts will be published in the December 27 *Eos*. The final program with presentation times will be distributed at the meeting. All scientific sessions will be held at the Fairmont Hotel.

Poster sessions will be held throughout the meeting from 9 A.M. to 5 P.M. AGU will provide each presenter with a mounting area measuring 1.25 × 2.50 m. Plan your poster display to fit this space. The boards will be set up in the designated room before the poster sessions begin. Thumb tacks, push pins, tape, and scissors will be available in the room.

Exhibits

Exhibits of equipment, programs, books, and organizations are planned to run daily from Tuesday, February 24, to Thursday, February 26, 9 A.M. to 4 P.M.

Special Sessions

Asterisk indicates new session.

Warm Core Rings
Air–Sea Interaction in Coastal Regions
*Ocean Instrumentation and Measurement Techniques
Shelf Dynamics
*OPUS
Optical Dynamics Experiment
Marginal Ice Zone Experiment
*Atmospheric Chemistry and Ocean Tracers
California Current and Eastern Boundary Currents
Regional Oceanography of the Gulf of Mexico and Caribbean Sea
Southern Oceans: Dynamics, Biomass
*Short Term Variability in Estuarine and Coastal Waters
*Long Term Changes of Nutrients in Estuarine and Coastal Waters
Kuroshio/Western Boundary Currents
Arctic Ocean: Dynamics, Biology, Acoustics
Dynamics of Submarine Rift in Vent Hydrothermal Systems: Biology, Geology, and Chemistry
*Physical and Biological Processes in Submarine Canyons
El Niño and Climate Variability
El Chichón, Global Climate, Chemistry
*Tropical Oceanography
Oceans and Atmospheric Chemistry: CO_2, N_2, Freons
Ocean Heat Transport: Models and Observations
Acoustic Monitoring: Suspended Particulates, Biology
Acoustic Remote Sensing: Fine Structure, Internal Waves, Mesoscale Features
Acoustic Imaging: Seafloor, Precision Bathymetry
Acoustic Tomography
Large Scale Ocean Observing Systems
*Small-Scale Ocean Processes and Structures
SAR Surface Signatures
*Fine and Micro Structure
Physical Oceanography and Ocean Tracers
Radioactive Waste Disposal
Environment and Fisheries Year Class Survival
*New Developments in Ocean Science Instrumentation: From A User's Perspective
Zooplankton Behavior
Plankton Productivity in Oligotrophic Waters
Interrelations of Optical and Biological Properties (including ODEX)
Below-Ground Processes in Wetland Ecosystems
Plankton Spatial Pattern—Growth and Behavior in a Turbulent Fluid
Dynamics of Microaggregates in Oceanic Systems
Phytoplankton Responses to Fluctuating Environments
*Interactions of the Mississippi River with the Gulf of Mexico
Aquatic Nitrogen Cycles
Biological and Physical Processes Within the Benthic Boundary Layer
*Recruitment: Starvation vs. Predation
Cyanobacteria: What Are They Doing?
*Contaminant Transport and Transformation Processes in Great Lakes Sediment
*Relationships between Benthic Ecology and Sedimentary Processes of the Venezuela Basin, Caribbean Sea: Past and Present
*Pollutant Transport by Particulates in Estuarine and Coastal Waters
Feeding Ecology of Fishes

Session Highlights

Zooplankton Behavior

Scope of session: research on individual zooplankton organisms, swarms, and other aggregations; communication/interaction within and between species; feeding, swimming; sensors and their performance; and laboratory and field observations. Cinema and video observations may be presented. Behavior in relation to abiotic factors (e.g., hydrographic variables) should be included. A general discussion on zooplankton behavior is scheduled to wrap up the session. Gustav-Adolf Paffenhöfer, Skidaway Institute of Oceanography, P.O. Box 13687, Savannah, GA 31406; 912-356-2489.

Belowground Processes in Wetland Ecosystems

Much of the primary production, decomposition, and element cycling in wetland ecosystems occurs below the sediment surface.

Meetings (cont. on p. 492)

RETURN THIS FORM WITH PAYMENT TO:
Meeting Registration
American Geophysical Union
2000 Florida Avenue, N.W.
Washington, DC 20009

PLEASE PRINT CLEARLY

NAME ON BADGE ______

AFFILIATION ______

MAILING ADDRESS ______

Telephone # ______

Days you plan to attend.
Please check appropriate box.
☐ Monday ☐ Wednesday ☐ Friday
☐ Tuesday ☐ Thursday

Members of the cosponsoring societies may register at AGU member rates.
☐ Member AGU ☐ Nonmember
☐ Member Cosponsoring Society
☐ ASLO-American Society of Limnology and Oceanography
☐ ASA-Acoustical Society of America
☐ AMS-American Meteorological Society
☐ MTS-Marine Technology Society
☐ OES-Institute of Electrical and Electronics Engineers Oceanic Engineering Society

Preregistrants
Your receipt will be in your preregistration packet. The registration fee will be refunded if written notice of cancelation is received in the AGU office by January 16. The preliminary program and meeting abstracts will appear in the December 27 issue of Eos and will be available at the meeting.

Nonmembers
The difference between member (or student member) registration and nonmember registration may be applied to AGU dues if a completed membership application is received at AGU by April 25, 1984. Current AGU annual dues are $20 Members; $7 Student Members.

AGU OCEAN SCIENCES MEETING
January 23-27, 1984
New Orleans, Louisiana

REGISTRATION FORM
Deadline for Receipt of Preregistration JANUARY 6, 1984

(Rates applicable only if received by January 6, 1984.)

	More than one day	One day
MEMBER	☐ $65.00	☐ $32.50
STUDENT MEMBER	☐ $32.00	☐ $16.00
NONMEMBER	☐ $85.00	☐ $42.50
STUDENT NONMEMBER	☐ $39.00	☐ $19.50
RETIRED SENIOR MEMBER	☐ $32.00	☐ $16.00
LUNCHEON, WEDNESDAY Jan. 25	☐ $12.00	☐ $12.00

All orders must be accompanied by payment or credit information. Make check payable to AGU.

Total Enclosed $ ______

Charge to: ☐ American Express ☐ Visa ☐ Master Card

Office Use: Code ______ Check No. ______

Card Number ______

Expiration Date ______

Signature ______

American Geophysical Union
OCEAN SCIENCES MEETING
January 23-27, 1984

Housing Reservation Form

Please note: Reservation must be received by December 23 to ensure space. All reservations must be guaranteed by enclosing payment for first night's deposit or by including American Express, Carte Blanche, or Diner's Club card number. Cancellations must be received by the hotel before 6 P.M. of the arrival date or the reservation will be billed for one night and the reservation canceled. All rooms are subject to city room tax.

Please Check Type of Accommodations
☐ Single $60
☐ Double $60

Mail Form Directly to:
Fairmont Hotel
Reservations Dept.
University Place
New Orleans, LA 70140

Arrival Date ______ AM ______ PM ______
Departure Date ______ AM ______ PM ______
Names ______
Address ______
City ______ State/Prov ______ Zip ______
Country ______
Telephone # ______

Please print or type. List names of both persons if double room.

Meetings (cont. from p. 491)

Will focus on such belowground processes in both freshwater and marine wetlands. Controls on belowground processes and comparisons of processes among wetland types will be emphasized. Robert Howarth, Ecosystems Center, Marine Biological Lab., Woods Hole, MA 02543; 617-548-3705.

Dynamics of Microaggregates in Oceanic Systems

Chemical, biological, and physical processes in the marine environment that control the formation, maturation, and fate of organic aggregates less than 100 microns in size. Emphasis will be on aggregate characterization, microbial food chain interactions at surfaces, and the role of microaggregates in the processing and flux of organic material in the water column. New methodologies for studying microaggregates will be discussed. Joel Goldman, WHOI, Woods Hole, MA 02543; 617-548-1400 x 2570.

Phytoplankton Responses to Fluctuating Environments

The importance of environmental fluctuations as a determinant in phytoplankton physiology, growth, and ecology. Presentations may deal with responses to fluctuating environments at any level of biological organization (including physiological, life history, and ecological and be either field or laboratory in nature. Of the environmental fluctuations, changing light and nutrient regimes will receive the greatest attention. David Turpin, Dept. Biology, Queens Univ., Kingston, Ontario, Canada K7L 3N6; 613-547-2724.

Interaction of the Mississippi River With the Gulf of Mexico

The present state of knowledge of the historical influence of the Mississippi River on the northern Gulf of Mexico, recent geomorphic changes, circulation in the vicinity of river plumes, the importance of the river in the geochemistry of trace metals, organic substances and radionuclides, the response of phytoplankton to nutrient inputs, oxygen dynamics, planktonic food chain relationships, and the importance of the river to regional fisheries. Donald Buesch, LUMCON, Star Route Box 541, Chauvin, LA 70344; 504-594-7852.

Aquatic Nitrogen Cycles

Biological and chemical processes controlling the fluxes of nitrogen among inorganic and organic nitrogen pools in water column and sediment systems. We would like to consider large and small scale nutrient dynamics and systems approaches to nitrogen budgets from estuarine to open ocean regimes. Bess B. Ward, Scripps Institution of Oceanography, A-018, UCSD, La Jolla, CA 92093; 619-452-4867.

Biological and Physical Processes Within the Benthic Boundary Layer

The properties of the benthic boundary layer affect the biological, sedimentological and chemical processes occurring therein. Will emphasize especially studies focusing on dynamic interactions among these subdisciplines, although more classical, unidisciplinary studies will not be precluded. James E. Eckman, Marine Sciences Research Center, SUNY, Stony Brook, NY 11794; 516-246-4026.

Cyanobacteria: What Are They Doing?

A great deal of data has accumulated to suggest that chroococcoid cyanobacteria are important primary producers which may be linked to other components of marine ecosystems by predation, symbioses, or excretion of dissolved organic matter. Will provide a forum for an open discussion of the role of cyanobacteria in planktonic and benthic systems. Theoretical or speculative papers will be considered and authors with new research data or who wish to summarize ongoing projects related to this area are encouraged to submit abstracts. A. Michelle Wood, Dept. Biophysics and Theoretical Biology, Univ. of Chicago, 920 E. 58, Chicago, IL 60637; 312-962-1391.

Contaminant Transport and Transformation Processes in Sediments of the Great Lakes

Will discuss contaminant-particle interactions, sediment focusing processes and time scales, historical records of contaminant deposition, postdepositional redistribution processes, mathematical models of bioturbation, fallout radionuclides as model contaminants, zoobenthos-contaminant interactions, and contaminant removal and resuspension processes and models. Should be of general interest to all concerned with the behavior of contaminants in both marine and freshwater environments. John Robbins, Great Lakes Environmental Research Lab., 2300 Washtenaw Ave., Ann Arbor, MI 48104; 313-668-2283.

Benthic Ecology and Sedimentary Processes of the Venezuela Basin: Past and Present

Will examine relationships between benthic ecology and sedimentary processes of the Venezuelan Basin, Caribbean Sea, from physical, chemical, geological and biological points of view. Past environments will be interpreted from the sedimentary record, paleocurrents and morphology of the basin itself. Papers on the present environment will focus on effects of benthic ecological processes on deep-sea sediments by organisms ranging in size from bacteria, meiofauna, macrofauna to megafauna. Rates of sediment mixing by bioturbation inferred from distributions of radioisotopes will be compared with geological, chemical, and biological data. Comparisons among sedimentary provinces of the Venezuela Basin and contrasts with other deep-sea environments will be made. David K. Young, Biological and Chemical Oceanography Branch, Oceanography Div., NORDA, NSTL Station, MS 39529; 601-688-4600.

Recruitment: Starvation Vs. Predation

What is the current state of knowledge regarding the long held assumptions that mortality of fish and other planktonic larvae are related to some combination of predation and starvation, and how do modern ideas of biological patchiness and micro- and finescale physical/chemical structure bear on this?

Acoustic Imaging

Focuses on the development and use of advanced acoustic measurement and imaging methods for studying or "viewing" the ocean bottom and for precision bathymetry. Specific systems of interest, applications and research results include SEABEAM, SEAMARC, SWATHMAP, DEEPTOW, etc. Gerald Morris, ONR, Bay St. Louis, MS.

Acoustic Sensing of Physical, Biological, and Sediment Properties

Focuses on the use of underwater acoustics to remotely infer various properties of the ocean, including sediment, meso- and finescale, and biological characteristics. Papers invited on acoustic doppler methods, backscattering from particulate matter, single and/or multifrequency back and forward-scattering techniques, multichannel seismic systems, deep tow geophysical systems, inverse methods, and planar hydrophone arrays.

Arctic Acoustics and Oceanography

Focuses primarily on Arctic acoustics, but also includes biological and dynamical properties of the Arctic. Specific topics of interest include ocean acoustics phenomena in the central and eastern Arctic and marginal ice zone and from the FRAM ice floe stations, emphasizing recent results in basin reverberation, propagation, scattering, geophysics, and ambient noise. Also of interest are papers on ice and biological dynamics, including empirical and theoretical studies on large- and small-scale ice and ocean dynamics, suspended particulates, phytoplankton, zooplankton, and higher tropic levels.

Observations of the 1982–1983 El Niño

Invites contributions reporting observations on all aspects of the 1982–1983 El Niño. In particular, observations from the coastal waters of North, Central, and South America are requested, as well as observations from the equatorial Pacific. David Enfield, School of Oceanography, Ore. State Univ., Corvallis, OR 97331; 503-754-4555.

OPUS

The Organization of Persistent Upwelling Structures (OPUS) study is an interdisciplinary program studying the function and variability of coastal upwelling. Will discuss results of the 1983 field work in the context of our developing understanding of shelf dynamics and its relation to biology. Burton Jones, USC, Institute for Marine and Coastal Studies, Los Angeles, CA 90007; 213-743-6848.

Shelf Dynamics

The results of recent fieldwork as well as modeling and theoretical results are invited to provide an integrated view of our new understanding of shelf dynamics. Rick Romea, Dept. Oceanography, Fla. State Univ., Tallahassee, FL 32306; 904-644-6702.

Short-Term Variability in Estuarine and Coastal Waters

Inshore waters are highly variable, but the variability often appears in stable frequencies of varying scales. Space and time domains of relevant physical and biological processes can control productivity and species abundances. Seeks the match between physical forcing and biological response. Joe Ramus, Duke Univ., Marine Lab., Beaufort, NC 28516; 919-728-2111.

Long-Term Changes of Nutrients in Estuarine and Coastal Waters

Will present and compare data on long-term changes in the nutrient status of estuarine and coastal waters. Long term refers to multiyear time series data; this limitation can be relaxed if enough contributors request such a change. Joe Ustach, Duke Univ., Marine Lab., Beaufort, NC 28516; 919-728-2111.

Southern Oceans

Will present contributions on all aspects of recent physical and biological work in the Southern Oceans; particular attention will be given to the interaction of the physical environment with the abundant biological resources of the region. Donald Siniff, Univ. of Minn., Dept. Ecology & Behavioral Biology, 318 Church St., Minneapolis, MN 55455; 612-373-4009.

Radioactive Waste Disposal

Will focus on recent research related to the disposal of low-level radioactive waste in the ocean. Contributions dealing with geology, physics, chemistry, and biology are invited to provide an integrated view of the current understanding of low-level disposal. Sherman Williams, Knolls Atomic Power Lab., Box 1072, Schenectady, NY 12301; 518-393-6611.

New Developments in Ocean Science Instrumentation: From a User's Perspective

Recent advances in oceanographic technology have enhanced the ocean scientist's ability to collect, transmit, and interpret field data. While some of these advances have resulted from the application of existing technologies to ocean science research, others have been developed to meet a specific need. Presents several such developments that have the potential for broad use by biological, chemical, geological, or physical ocean science investigators. Papers are requested to augment several that will be invited. Lawrence Clark, Oceanographic Technology Program, NSF, 1800 G St., N.W., Room 613, Washington, DC 20550; 202-357-7857.

Regional Oceanography of the Gulf of Mexico and Caribbean Sea

Relationships between biological, chemical, geological, and physical processes and the circulation and water mass distributions found within the Gulf of Mexico and Caribbean Sea. John Morrison, Ocean Dynamics Program, NSF, 1800 G St., N.W., Washington, DC 20550.

Small-Scale Ocean Processes and Structures

The fine- and microstructure of ocean scalar and velocity fields. Turbulence; temperature and salinity microstructure; double diffusive convection; mixing. Relationship of the small-scale ocean physics to the larger scale temperature, salinity, and velocity finestructure field. The relative importance and observational evidence for various types of ocean microstructure. Steven Mack, JHU, APL, Johns Hopkins Road, Laurel, MD 20707; 301-953-7100.

SAR Surface Signatures

surface and internal gravity wave generation, propagation and transformation; spatial evolution and forecasting of ocean wave spectra; properties of the mesoscale wind field; SAR modulation mechanisms, both theory and experiment; development of algorithms for quantitative measurements of wind, waves, currents, bathymetry, and ice. R. C. Beal, JHU, APL, Johns Hopkins Road, Laurel, MD 20707; 301-953-7100.

Dynamics of Submarine Rift in Vent Hydrothermal Systems: Biology, Geology, and Chemistry

The understanding of the interrelationships between the geologic setting, the biota, and chemistry of the diverse submarine hydrothermal vents. This understanding is necessary in order to unravel the evolution of the vent communities and to understand the differences in the chemistry of the metalliferous precipitate of the vents. Alexander Malhoff, NOAA.

Ocean Heat Transport: Models and Observations

Role of large scale heat and fresh water transport in the ocean circulation. Estimate of heat transport based on both atmospheric and ocean measurements and the interpretation provided by numerical models. Kirk Bryan, NOAA/GSDL.

Large Scale Ocean Observing Systems

There has been a change in scientific focus for satellite-based ocean observations over the past 4 years, from a concern with quality of data associated with a given sensor technique to an emphasis on technique application to specific problems. Will address the application of satellite technique to oceanic problems such as circulation, response to wind, fertility, sea ice cover, etc. W. Stanley Wilson, NASA.

Ocean Chemistry in the CO_2 Cycle

Applications of chemical data collected during the transient tracer in the ocean program. Emphasis on progress in understanding the CO_2 cycle and to early results from the Amazon estuary data. R. M. Key, Princeton Univ., Princeton, NJ; 609-452-3595.

Oceanography and Ocean Tracers

Preliminary examination of the physical oceanographic data collected during the North Atlantic and Tropical Atlantic Transient Tracers in the Ocean programs. Application of chemical tracer data to modeling ocean transport and diffusion problems. R. M. Key, Princeton Univ., Princeton, NJ; 609-452-3595.

Meeting Report

Chapman Conference

It is becoming clear that point defects in minerals play a role in processes important to the formation and evolution of the earth. Processes such as diffusion, electrical conduction, thermal conduction, creep, and sound propagation all exhibit behavior that can either be directly attributed to the influence of defects or can be shown to be related to their presence. In some cases (diffusion, electrical conduction, creep), point defects seem to play a central role in the behavior.

The goal of the Chapman Conference, held at Fallen Leaf Lake, Calif., September 5–9, 1982, was to bring together a variety of experts from within the geosciences and those materials-science disciplines that have traditionally studied the role of point defects in solids to examine the role of defects in minerals. In this sense, the conference was the first of its kind; and while there have been many dealing with point defects, none had dealt with their role in minerals and before an audience comprising a significant number of earth scientists. Of the 71 participants, 17 were decidedly nonearth science in their outlook, and 12 represented five countries other than the United States. An anticipated outcome of the conference was to expose earth scientists to the state of the art in point-defect science and to expose nonearth scientists to current problems of geochemistry and geophysics.

The existing knowledge about point defects, their treatment as chemical entities, and their behavior was covered by F. A. Kröger (University of Southern California) on thermodynamics, B. Wuensch (Massachusetts Institute of Technology) on diffusion, H. L. Tuller (Massachusetts Institute of Technology) on electrical conduction, and R. Gordon (Ceramatec, Utah) on creep. C. R. A. Catlow (University College, London) on computer modelling of defects in solids and S. A. Brawer (Lawrence Livermore National Laboratory) on molecular dynamics of defects in melts added the state of the art in modeling. A tutorial of some of the problems in geochemistry and geophysics that might be related to, or solved by an understanding of, point defects was given by A. Navrotsky (Arizona State), A. C. Lasaga (Pennsylvania State University), T. J. Shankland (Los Alamos National Laboratory), and R. N. Schock (Lawrence Livermore National Laboratory).

Wuensch noted that there were many pitfalls in diffusion experiments. Diffusion is strongly affected by mechanical damage in preparing a sample, with likely effect on other kinetic processes. In addition, impurities at the 200- to 300-ppm level can have marked effects on transport properties. Finally, experimenters often do not allow a sufficient amount of time for diffusion of various components to take place and for equilibrium to be established.

Diffusional creep phenomena in polycrystalline oxides can be used to provide insight as to how silicates are likely to behave. Gordon pointed out that electrical conductivity results from the majority carriers, while creep is likely to be the result of minority carriers; thus, activation energies for the creep process are misleading and are not indicative of the defects involved. Tuller reminded everyone that electrical conduction processes in simple oxides are complex and are likely to be even more complex in silicate minerals. Since the band gap in mantle silicates has been shown to be large (8 eV), intrinsic electronic conduction is replaced by impurity controlled extrinsic and ionic conduction. Electrical conductivity measurements may be used to identify the major ionic and electronic defects in a particular system as well as the thermodynamic quantities that characterize their generation and association.

Catlow extended computer simulation methods from simple oxides to minerals. Such calculations allow the prediction of crystal structures, physical properties, and potential structures, physical properties, and point defect structures. Brawer presented computer simulation studies on defects in BeF_2 liquids, which he believes serve as analogues to SiO_2. The model predicts viscosity decreasing with pressure for both melts. Threefold coordinated anions and fivefold coordinated cations are possible defects in the melt, and any diffusion with the resulting separation of a cation-anion nearest neighbor pair would be predicted to occur only at the site of a threefold coordinated anion (i.e., oxygen in SiO_2).

The possibility that perovskite structures and other phases might exhibit superconductivity close to their melting temperatures in the mantle was raised by M. O'Keeffe (Arizona State) in discussing solid electrolyte transitions. Not only are the conductivities of such solid electrolytes very high, their mechanical moduli are anomalously low. O'Keeffe stressed that short-range interatomic forces are very important and that the force field in silicon-oxygen arrangements may be such that the effective radius of the silicon is larger than that for oxygen. An excursion outside the realm of point defects was made by David Veblen (Johns Hopkins), who discussed his recent observations with high resolution transmission electron microscopy and the role that planar defects (grain boundaries and stacking faults) play in critical mineralogical processes. His stunning electron photomicrographs provide visual evidence that planar defects control diffusion and therefore the rate of chemical reactions. Some conclusions from Veblen's visual panoramas are that grain boundaries are not necessarily the chemical "garbage cans" that many have supposed and that many rock-forming minerals are nonstoichiometric. Planar defects, common in chain and sheet silicates, do not, however, appear to exist in olivine.

A wide variety of other papers attests to the growing realization that defects play a very important role in the properties of minerals, and still other papers dealt with measurements of the properties of melts, anelasticity, atomic distributions at atomic sites in silicates, and electrical conductivity. It is important to note that the electrical conduction mechanisms appear to be very different in iron-bearing natural olivine from those in the synthetic pure-magnesian forsterite. Combined with the results on creep and on diffusion, these results indicate that iron strongly affects point defect chemistry in olivine and that the oxidation state of the iron plays an equally significant role. The interest and enthusiasm around this meeting promise a more intense effort at understanding the role of point defects in minerals than we have seen in the past. A better understanding of properties within the earth should be forthcoming.

This meeting report was contributed by R. N. Schock, Lawrence Livermore National Laboratory, Livermore, CA 94550.

EDITOR'S NOTE: *Point Defects in Minerals,* a collection of papers from this Chapman Conference, will be published as a part of the AGU Geophysical Monograph Series and will be edited by R. N. Schock. Publication will be early 1984.

Abstracts

Vibrational and Electronic Properties of Crystals: The Role of Local Bonding.

A.B. ANDERSON (Chemistry Department, Case Western Reserve University, Cleveland, Ohio 44106)

During initial crystal growth stages, structures and compositions depend on equilibrium thermodynamics. Given the bulk structure, quantum chemical calculations using cluster models can yield details of the electronic spectra associated with bulk-coordinated atoms, cations, and anions. In some cases bulk lattice constants and stretching force constants can be calculated from cluster models or from simple physical theories. Several examples of such studies using the author's "atom superposition and electron delocalization" molecular orbital theory will be mentioned. The optical spectra of hematite and ferrous defects in hematite will be discussed in greater detail. Wurtite will be included. The optical, photoemission, magnetic, and conducting properties of magnetite will be put into the molecular orbital framework of understanding.

Point Defect Behavior in the Reduction of Olivine

J. W. BOLAND (IVAU) P.O. Box 80.021, 3508 TA Utrecht, The Netherlands
A. G. DUBA (Lawrence Livermore National Laboratory, P.O. Box 808, Livermore, California, 94550, USA)*

We will illustrate the importance of defect structures in the nucleation and growth properties of iron-nickel precipitates in olivine that has been reduced at temperatures to 1400°C, for times up to 30 hours, using CO/CO_2 mixtures to control the oxygen fugacity, fO_2. An overall reaction for the reduction is $Mg_2SiO_4 + Fe_2SiO_4$ = $2 MgSiO_3 + 2 Fe + O_2(g)$; the "fayalite" component is reduced to a metallic phase and the resulting excess silica reacts with the "forsterite" component to produce pyroxene with gaseous oxygen evolved. However, the mechanistic pathways for this reduction are not unique and our electron microscopy studies show a marked difference between the microstructures developed in the surface regions and those deeper in the olivine. As an example, at 1300°C, $fO_2 \sim 10^{-14.5}$, 3 1/3 hours, the precipitate number density in the olivine varies from $\sim 10^{13}/cm^3$ in the surface region (zero to 10 μm deep) to a density of $\sim 10^{9}/cm^3$ at 0.7 mm depth. The average dimensions of the metallic particles in both regions is 0.15 μm x 0.17 μm x 0.07 μm. The reduction of nickel appears to precede iron in the olivine lattice leading to nickel-rich precipitates in the center (Ni/Fe ~ 3/1) compared with more dilute alloys at the surface (Ni/Fe ~ 1/3). In both regions, the residual olivine must be nonstoichiometric with the degree of nonstoichiometry proportional to the amount of precipitate formed. No pyroxene was found in the sample and the only evidence that might be interpreted as the presence of an oxygen phase was bubble formation in the surface layer.

*Work performed under the auspices of the U.S. Department of Energy by the Lawrence Livermore National Laboratory under contract number W-7405-ENG-48.

COMPUTER SIMULATIONS OF FLUIDS WITH APPLICATIONS TO BeF_2, SiO_2 AND BINARY MELTS

STEVEN BRAWER, Lawrence Livermore National Laboratory

The computer simulation of liquids by the Molecular Dynamics technique involves a numerical integration of Newton's equations of motion for several hundred particles in a box of appropriate density. [illegible]

*Work performed under the auspices of the U.S. Department of Energy by the Lawrence Livermore National Laboratory under contract number W-7405-ENG-48.

Pauling Solid Solutions: Composition Limits Controlled by Vacancies

C. W. BURNHAM (Dept. of Geological Sciences, Harvard University, Cambridge, MA 02138)
M. M. BEGER (Champlain Regional College, Lennoxville, Quebec J1M 2A1, Canada)

[illegible]

Computer Modelling of Minerals

C.R.A. CATLOW (Dept. of Chemistry, University College London, UK)

Computer simulation techniques have now reached success in quantitative studies of the formation energies of defects in inorganic solids. [illegible]

Network of Atomic Diffusional Jumps in Olivine

R. H. CONDIT (Lawrence Livermore National Laboratory, Livermore, CA 94550)

Diffusion in olivine may take place through several distinct oxygen jumps. [illegible]

Work performed under the auspices of the U.S. Department of Energy by the Lawrence Livermore National Laboratory under contract number W-7405-ENG-48.

Oxygen Grain Boundary Diffusion in Forsterite and Mantle Processes

R. H. CONDIT
H. C. WEED
A. J. PIWINSKII (University of California, Lawrence Livermore National Laboratory, Livermore, CA 94550)

We have developed a technique for measuring oxygen diffusion along grain boundaries. [illegible] provides a preferred path for oxygen diffusion. [illegible]

Work performed under the auspices of the U.S. Department of Energy by the Lawrence Livermore National Laboratory under contract number W-7405-ENG-48.

The Nature and Role of Point Defects in Spinels

A.N. CORMACK, G.V. LEWIS, S.C. PARKER and C.R.A. CATLOW (Dept. of Chemistry, University College London, UK)

Recent improvements in both hardware and software have enabled the extension of atomistic computer modelling techniques to complex inorganic compounds. [illegible]

Mechanisms of Crack Healing in Olivine

Brian Evans and S.J. Wanamaker (Dept. Geological and Geophysical Sciences, Princeton University, Princeton, NJ 08544)

[illegible]

Oxygen Diffusion in Silicate Minerals

BRUNO J. GILETTI (Dept. of Geological Sciences, Brown University, Providence, RI 02912)

[illegible]

Diffusional Creep Phenomena in Polycrystalline Oxides

RONALD S. GORDON (University of Utah, Salt Lake City, Utah 84112)

[illegible]

The Influence of Changes in the Fermi Level Upon the Creep Rate in Minerals

B.E. HOBBS (Department of Earth Sciences, Monash University, Clayton, 3168, Australia)

This paper discusses the general theory of creep in non metals by dislocation motion; contrasts with the situation in metals are highlighted. [illegible]

OXYGEN DIFFUSION IN FORSTERITE AND OLIVINE: TECHNICAL IMPROVEMENTS AND DISCUSSION OF POINT DEFECTS

O. JAOUL, B. Houlier, C. Froidevaux (Laboratoire de Géophysique et Géodynamique Interne, Université Paris-Sud, Bât 510, 91405 Orsay Cedex, France).

[illegible]

A new apparatus for high pressure studies of anelasticity at seismic frequencies

M.S. PATERSON Research School of Earth Sciences, Australian National University, Canberra, Australia
I. JACKSON

[illegible]

Creep of Hydrolytically-weakened Synthetic Quartz Crystals: Effects of Hydroxyl and Other Impurities

S. W. KIRBY
J. MCCORMICK (both at U.S. Geological Survey, Menlo Park, CA 94025)

[illegible]

POINT DEFECTS IN SOLIDS — PHYSICS, CHEMISTRY AND THERMODYNAMICS

F. A. KRÖGER, Department of Materials Science, University of Southern California, University Park, Los Angeles, CA 90089-0241

Abstract

[illegible]

*Work supported by the U.S. Department of Energy under Contract No. [illegible]

Point Defects and Geochemical Processes

LASAGA, ANTONIO C., Dept. of Geosciences, The Pennsylvania State University, University Park, Pa. 16802

[illegible]

Meetings (cont. on p. 494)

Meetings (cont. from p. 493)

geochemical processes. The relation between oxygen fugacity and the defect structure of minerals is essential in interpreting the intrinsic oxygen fugacity measurements of many natural systems. In particular, discrepancies between the intrinsic fO_2 values and those predicted from natural mineral assemblages are related to the thermal behavior of defect concentrations. Defects are essential in (a) the homogenization of zoned crystals, (b) the alteration of the composition of minerals, (c) changes in the order-disorder status of tetrahedral cations in aluminosilicates, (d) the resetting of radiometric ages, (e) isotope equilibration, (f) creep in the earth's mantle, (g) formation of exsolution lamellae, and (h) the growth and dissolution of minerals. The first four examples (a-d) are related to the general process of bulk diffusion, which is only possible due to the existence of point defects. The next four (e-h) may be controlled by point defect diffusion or by yet another type of defect, extended defects, e.g., dislocations. Systematization of diffusion data (both tracer and interdiffusion) for minerals can be done if the defect structure is properly understood. Finally, the proper treatment of polarization due to point defects will be needed to model the structure of silicate melts.

Electrical Studies of Transition Metal Cation Distribution in Spinels

T. O. MASON (Dept. of Materials Science and Engineering and Materials Research Center, Northwestern University, Evanston, IL 60201)

Cation distributions of transition metal cations in oxide spinels can be investigated via thermoelectric coefficient measurements over a broad range of temperatures. This is made possible by the small polaron "hopping" of charge carriers between different valence states of a given transition metal ion on equivalent crystallographic sites. From the thermopower, a valence ratio can be determined from which the overall cation distribution can be calculated. Results in Fe_3O_4, from which the cation distribution thermodynamics were established, will be reviewed. Ferrite data at low temperatures in the system ...

Point Defects, Mineral Stability, and High Pressure Silicate Phases

ALEXANDRA NAVROTSKY (Department of Chemistry, Arizona State University, Tempe, AZ 85287)

Effect of Point Defect Concentrations on Cation Diffusion in Olivine

MASAMI MORIOKA (Radioisotope Centre, University of Tokyo, Yayoi, Bunkyo-ku, Tokyo 113 Japan)

The Solid-Electrolyte Transition and Some Geochemical Implications

M. O'KEEFFE (Department of Chemistry, Arizona State University, Tempe, AZ 85287)

Prediction of Mineral Crystal Structures

S.C. PARKER (Dept. of Chemistry, University College London, UK)

... the structural properties of minerals. It is essential to model the perfect mineral structures before the defect processes are studied. The work presented here shows that we can now correctly calculate the structures of a wide range of minerals, including a number of silicates.

Our approach is based on the derivation of potential models from which the predicted structure is calculated by energy minimization.

This study was primarily concerned with ortho and meta silicates and we will show that we can (i) model the distortions from ideal or close-packed structures due to the presence of different cations (ii) discriminate between a number of space groups with the same formula unit (iii) calculate the effects of pressure on the mineral structure.

The Nature of the Water-related Defect in Hydrolytically-weakened Quartz

M. S. PATERSON (Research School of Earth Sciences, Australian National University, Canberra 2600, Australia)

The phenomenology of hydrolytic weakening in quartz will be reviewed with a view to defining constraints on the nature of the defect associated with the weakening. Many of the observations have been published but some recent unpublished work will also be covered. The observations comprise stress-strain measurements as a function of temperature, pressure and water environment, infrared absorption observations at room temperature and low temperature, studies involving the precipitation of water from "wet" crystals during annealing, and sundry other observations including diffusion and other spectroscopy. Recent suggestions by Kirby and by McLaren, that a defect is involved which consists of four hydrogen atoms substituted for a silicon atom in the quartz structure, will be particularly discussed.

Cation Demixing in Crystalline and Molten Oxides

W. T. PETUSKEY (Department of Ceramic Engineering, University of Illinois, Urbana, IL 61801)

Cations in initially homogeneous, oxide solid solutions segregate under the influence of imposed temperature gradients, oxygen potential gradients ...

Experimental Evidence for an Effect of Chemical Environment on the Creep Rate of Olivine

D.L. KOHLSTEDT (both at: Department of Materials Science and Engineering, Cornell University, Ithaca, NY 14853)

High Temperature AC Electrical Property of Olivine Single Crystals with Varying Oxygen Fugacity

HIROKI SATO

Estimating Activation Parameters Using Elastic Continuum Models

CHARLES G. SAMMIS and John C. Seith, Department of Geological Sciences, University of Southern California, Los Angeles, California 90007

Olivine Electrical Conductivity As A Function of Oxygen Fugacity

R. N. Schock, (University of California, Lawrence Livermore National Laboratory, P. O. Box 808, Livermore, CA 94550)

Work performed under the auspices of the U.S. Department of Energy by the Lawrence Livermore Laboratory under contract number W-7405-ENG-48.

Role of Point Defects on Geophysics

T. J. SHANKLAND (Los Alamos National Laboratory, Los Alamos, NM 87545)
R. N. SCHOCK (Lawrence Livermore Laboratory, Livermore, CA 94550)

Electrical Conduction in Ceramics and Disordered Materials

HARRY L. TULLER (Department of Materials Science & Engineering, Massachusetts Institute of Technology, Cambridge, MA 02139)

HIGH PRESSURE ELECTRICAL CONDUCTIVITY IN MOLTEN NATURAL SILICATES

Point Defects in Minerals: Chemical and Physical Consequences

DAVID R. VEBLEN (Department of Earth and Planetary Sciences, The Johns Hopkins University, Baltimore, Maryland 21218)

The Electrical Conductivity of Compounds Containing a Dispersed Second Phase

J. BRUCE WAGNER, JR. (Center for Solid State Science, Arizona State University, Tempe, AZ 85287)

Cation Distribution Equilibria in Ferroelite, $MgTi_2O_5$

CAROL A. WECHSLER and ALEXANDRA NAVROTSKY (Department of Chemistry, Arizona State University, Tempe, AZ 85287)

Can the Electrostatic Potential in Ferroelite Explain the Observed Cation Distribution in Olivines and Its Dependence on the Oxygen Fugacity?

S. WILL, A. Kirfel, G. Will and G. Hoser, Mineralogisches Institut, University Bonn, West Germany

Techniques, Results and Pitfalls for Measuring Diffusion in Oxides

BERNHARDT J. WUENSCH (Department of Materials Science & Engineering, Massachusetts Institute of Technology, Cambridge, MA 02139)

... implantation, and the use of stable isotopes as tracers. Measurements have been extended for some materials to temperatures as high as 2600°C, closer to the melting temperature than previously examined.

Diffusion coefficients obtained by different workers for simple, stoichiometric close-packed oxides are generally not in good agreement. Discrepancies of several orders of magnitude for a given material are the rule, rather than the exception. Spurious results can arise from factors such as inadequate control of impurity content, surface damage incurred during the preparation of surfaces on the host crystal, impurities carried by the tracer or created by decay of a radioactive tracer, variation of diffusivity with concentration, incomplete equilibration of a sample with its atmosphere, or vaporization of material during the diffusion annealing.

Geophysical Year

New Listings

The complete Geophysical Year last appeared in the May 31, 1983, *Eos*.

A boldface meeting title indicates sponsorship or cosponsorship by AGU.

Aug. 22–26, 1983 British Association for the Advancement of Science, Brighton, UK. (British Association for the Advancement of Science, 23 Savile Row, London W1X 1AB, UK.)

Oct. 22–28, 1983 7th International Estuarine Research Conference, Virginia Beach, Va. Sponsor, Estuarine Research Federation. (John Kreauter, ERF Treasurer, Crane Aquaculture Facility, BG&E, P.O. Box 1475, Baltimore, MD 21203.)

Dec. 5–9, 1983 Second South East Asian Survey Congress, Hong Kong. Sponsor, Hong Kong Branch of the Royal Institution of Chartered Surveyors and Hong Kong Institute of Land Surveyors. (Congress Secretariat, Second South East Asian Survey Congress, 57 Wyndham Street, 1st Floor, Central, Hong Kong.)

Feb. 23–24, 1984 15th Meeting, International Erosion Control Association, Denver, Colo. (International Erosion Control Association, Inc., P.O. Box 807, Freedom, CA 95019; tel.: 408-688-3228.)

March 14–17, 1984 1984 Meeting, Geological Society of America Hydrogeology Division, Northeast Section, Providence, R. I. (Jeff Sgambat, Geraghty and Miller, Inc., 844 West Street, Annapolis, MD 21401; tel.: 301-268-7730.)

May 20–25, 1984 International Symposium on Deep Observation and Sampling of the Continental Crust Through Drilling, Tarrytown, N. Y. (Barry Raleigh, Director, Lamont-Doherty Geological Observatory, Palisades, NY 10964; tel.: 914-359-2900.)

Summer 1985 Colloquium on Comparative Study of Magnetospheric Systems, France. (Dominique Le Quéau and Bent Møoller-Pedersen, DASOP, Observatoire de Meudon, F 92195, Meudon Principal Cedex, France; Telex: 200 590 CNET OBS.)

Changes

May 29–June 1, 1984 Joint Meeting of the 11th Annual Meeting of the Canadian Geophysical Union and the 18th Annual Congress of the Canadian Meteorological and Oceanographic Society, Halifax, Nova Scotia, Canada. (New contacts: S. D. Smith or H. R. Jackson, Bedford Institute of Oceanography, P.O. Box 1006, Dartmouth, Nova Scotia, Canada B2Y 4A2.)

GAP

Separates

To Order: The order number can be found at the end of each abstract; use all digits when ordering. Only papers with order numbers are available from AGU. *Cost:* $3.50 for the first article and $1.00 for each additional article in the same order. Payment must accompany order. Deposit accounts available.

Send your order to:
American Geophysical Union
2000 Florida Avenue, N.W.
Washington, D.C. 20009

Aeronomy

0350 Tides, waves and winds
DIURNAL VARIATIONS OF LOWER THERMOSPHERIC WINDS FROM THE MILLSTONE HILL INCOHERENT SCATTER RADAR
J. E. Wand (Haystack Observatory, Westford, Massachusetts, 01886)

From July 1976 to November 1977 regular incoherent scatter observations of E and F region ion-drifts were conducted at Millstone Hill (42.6°N) with the steerable (L-band) and fixed (UHF) radars. Data were collected on a total of 46 days and analyzed for ionospheric electric fields ...

0460 Tides, waves and winds
AN ANALYTIC SOLUTION FOR THE RESPONSE OF THE NEUTRAL ATMOSPHERE TO THE HIGH-LATITUDE CONVECTION PATTERN
I.S. Mikkelsen (Danish Meteorological Institute, Lyngbyvej 100, DK-2100 Copenhagen, Denmark) and M.F. Larsen

We develop the analytic solutions to a two-dimensional, shallow-water model of the high-latitude thermosphere. The equations are a linearized representation of the response of the neutral atmosphere to the ...

Exploration Geophysics

0910 Computer applications

0920 Magnetic and electrical methods

0930 Seismic methods

0999 General or miscellaneous

8920 Magnetic and electrical methods
A MISE-A-LA-MASSE STUDY OF THE CAVENDISH GEOPHYSICAL TEST SITE
... (Department of Geophysics, The University of Western Ontario, London, Ont., Canada N6A 5B7) ...